21324-6002-RU-00

MISSION REQUIREMENTS FOR A MANNED EARTH OBSERVATORY

TASK 2 — REFERENCE MISSION DEFINITION AND ANALYSIS

Contract No. NAS8-28013

31 May 1973

VOLUME II

Prepared for

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Marshall Space Flight Center, Alabama 35812

Prepared by

TRW SYSTEMS GROUP/EARTHSAT

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ONE SPACE PARK • REDONDO BEACH, CALIFORNIA 90278

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FOREWORD

The documentation on the "Mission Requirements for a Manned Earth Observatory" study, performed for the NASA Marshall Space Flight Center, Huntsville, Alabama, under Contract NAS8-28013 resulted in a four volume report. These volumes are:

Volume I	Task 1 — Experiment Selection, Definition and Documentation. Report No. 21324-6001-RU-0(, 12 April 1973
Volume II	Task 2 — Reference Mission Definition and Analysis. Report No. 21324-6002-RU-00, 31 May 1973.
Volume III	Task 3 — Conceptual Design. Report No. 21324-6003-RU-00, 31 May 1973.
Volume IV	Task 4 — Programmatics. Report No. 21324-6004-RU-00, 31 May 1973.

On this study, TRW Systems was contractually assisted by Earth Satellite Corporation, Washington, D. C., and by Model Development Laboratory, Alhambra, California.

The contents of these reports pertain to the mission requirements and conceptual design of Shuttle sortie payloads that could be flown in the 1980s. In developing this information, projections of 1980 sensor technology and user data requirements were used to formulate "typical" basic criteria pertaining to experiments, sensor complements, and reference missions. These "typical" criteria were then analyzed in depth to develop conceptual payloads that are within the capabilities of the Shuttle/Sortie Lab mission capabilities. These payloads, therefore, should not be considered to be potential candidates for Shuttle missions, but only as typical conceptual payloads.

Future studies will be directed more specifically to the development of requirement and conceptual designs for potential Shuttle payloads, such as a Manned Earth Observatory that would be used as a sensor development Laboratory and to accommodate unique data acquisition requirements that would be supportive and complementary to the earth observations automated satellite programs.

Additional information pertaining to this document may be obtained from the NASA Contracting Officer's Representative, Mr. Donald K. Weidner, Marshall Space Flight Center, Huntsville, Alabama 35812.

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1.0 INTRODUCTION

In Task 1, the 60 candidate experiments originally compiled by the study disciplinarians were subjected to three filters in order to permit the selection and justification of those experiments which could best be performed on the Shuttle (see Figure 1-1). The three filters were:

- Experiment characteristics
- Importance
- Technology

The 54 experiments which successfully passed these filters were documented according to one of three formats which reflected the experiment's applicability to early Shuttle Sortie reference missions, and particularly, their applicability to the derivation of mission requirements (see Volume 1). The class of experiments within each documentation level were:

- Level 1 - potential reference mission experiments.
- Level 2 - experiments that were considered applicable to early Shuttle Sortie missions but they were of lower overall importance than Level 1 experiments and all the measurement/observation requirements had not yet been determined.
- Level 3 - experiments of lower overall importance than those of Level 1 or 2 and/or many important elements remain to be defined.

Thirty Level 1 experiments were documented. These were used to develop reference missions.

In preparation for experiment scheduling and mission time-lining, the Level 1 experiment sensors were further defined and specified in terms of their performance/physical characteristics and platform considerations.

The guidelines used in synthesizing reference missions were specific, in that they addressed the 30 Level 1 experiments, and general, in that consideration was given to capabilities of the Shuttle. A total of nine reference missions were selected as potential MEO missions and prioritized in terms of their relevancy for user needs of the late 1970s and early 1980s.

These nine prioritized reference missions were divided into three groups (see Figure 1-1). The first mission was carried through a complete computer mission analysis which included orbital optimization, experiment scheduling and resource summaries.

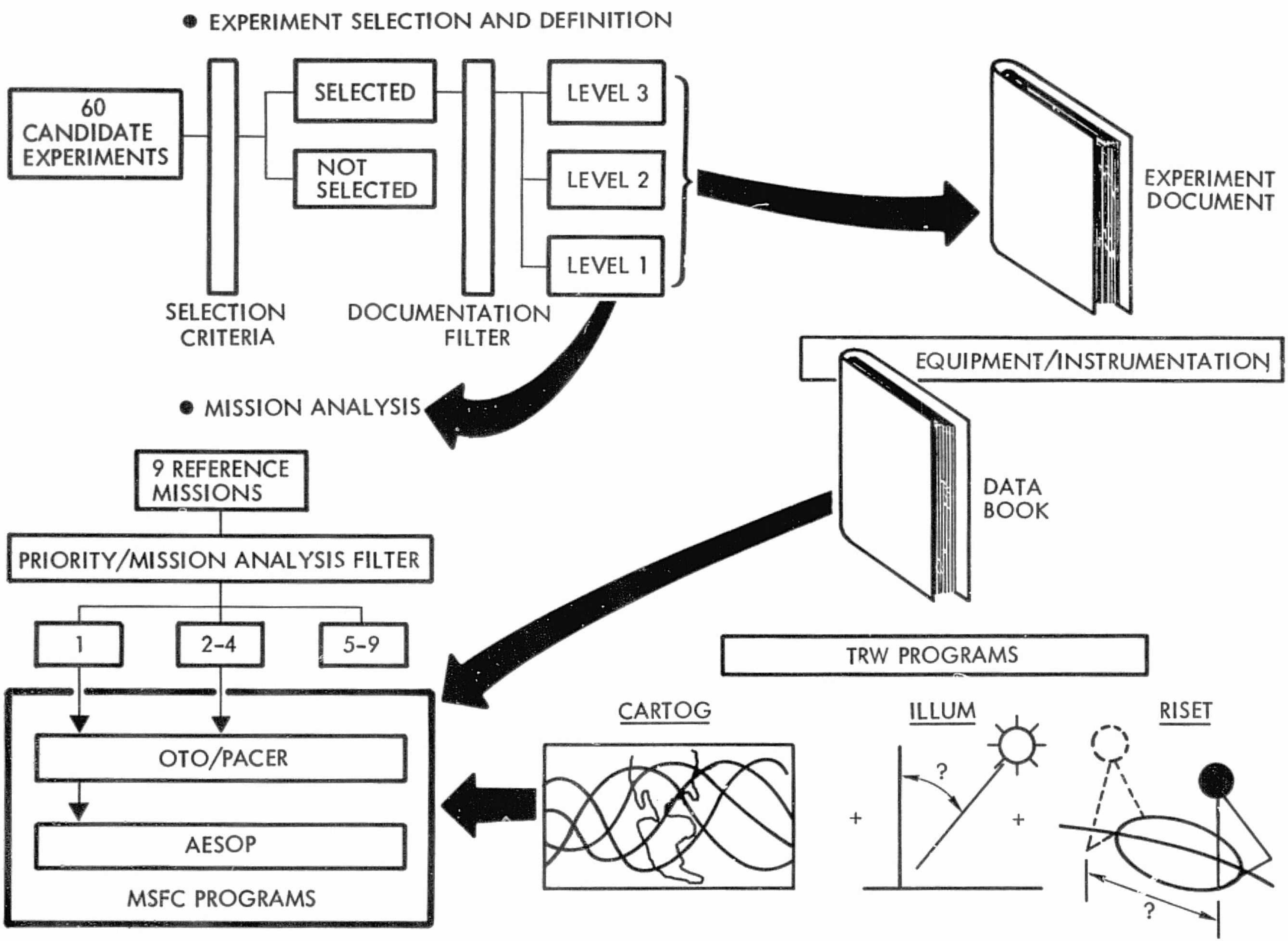

Figure 1-1. Inputs to Mission Analysis

The second group of missions was carried through the orbital optimization to obtain a typical range of orbit requirements for earth observation Shuttle missions. The third group consisted of the reference missions of lower overall importance and were not carried through a computer analysis.

The first phase of the computer mission analysis used two computer programs (OTO and PACER) to provide orbital optimization. If the observation requirements for a mission were expressed in terms of frequency of coverage, OTO was used. If the objective was to cover as much of the target areas as possible, and the frequency of coverage was unimportant, then PACER was used. For the four reference missions analyzed, OTO was required for orbital optimization.

Once the optimal orbit was established, three additional computer programs were employed to evaluate the selected orbit in detail in preparation for experiment scheduling. This evaluation considered:

	Program
• Illumination conditions	ILLUM
• Additional targets along the subsatellite trace	CARTOG
• Data station acquisition and loss times	RISET

After evaluating the first priority reference mission the orbit remained unchanged and no additional targets were added. OTO was then rerun to generate an ephemeris tape.

The experiment scheduling program, AESOP, required the following inputs:

- Sensor data bank
- Mission/experiment priorities
- Ephemeris tape

These inputs were compiled and AESOP was run for the first priority reference mission.

The output of AESOP consisted of:

- Experiment timelines
- Sensor timelines
- Data requirements (digital and film)
- Power requirements.

These were then analyzed in terms of sensor/experiment/mission commonality, role of man and data handling and management.

In addition to the analysis discussed above, the pollution mission was also evaluated in terms of its on-call capability for disaster assessment and its contribution to a multistage sampling program.

The 29-sensor pollution reference mission that was carried through the complete computer analysis is a complex and sophisticated mission which not only taxes the Shuttle Sortie Lab capabilities, but is rather expensive. To reduce the cost of this, as well as other missions, a low-cost mission definition rationale was developed. The effect of applying such a rationale to the pollution mission was then demonstrated.

2.0 MISSION SELECTION AND PRIORITIZATION

2.1 SELECTION CRITERIA

References missions or assemblages of experiments may emphasize:

a) Phenomena — Experiments emphasizing the acquisition of data dealing with air pollution, water pollution, eutrophication, floating debris, etc., would constitute a large, important area of investigation. So, too, would experiments addressing the inventorying and monitoring of ice (sea, pack, etc.), snow (pack, melt, etc.), ice dams, and state of the ground.

b) Geographical Areas — Many experiments which are both multidisciplinary and multi-phenomenon oriented emphasize particular areas, such as bays, coastlines, and urban areas.

c) Disciplines — Individual disciplines (e.g., agriculture, geology, meteorology, etc.) would provide the experiments that receive the greatest emphasis in a reference mission experiment assembly. There are also natural groupings of disciplines that relate to each other by virtue of the proximity of their targets and/or by virtue of the close interactive relationship that the disciplines bear to each other, as in meteorology and oceanography.

d) Time of Year — Many experiments have observables with specific temporal requirements. (e.g., early spring, winter solstice, etc.).

Choosing one of these categories as a central theme forms a selection foundation upon which a group of related experiments can be compiled.

In order to drive out mission requirements, accommodate a large section of the user community and still create a feasible reference mission, several additional guidelines were used:

- The mission should contain a reasonable mix of applications, research and operational experiments to accommodate as many users as possible.
- A sufficient number of experiments and sensors should be selected to utilize the experiment crew.
- All 30 Level 1 experiments should be used in at least one reference mission and each mission should have new experiments. By changing the experiment composition of missions, various interactions can be observed in terms of mission requirements.
- The mission should have a capability for on-call disaster warning/monitoring/assessment to monitor important targets of opportunity.
- The mission should supplement and complement automated programs.

2.2 MISSION SELECTION

Applying the selection criteria to the group of Level 1 experiments resulted in nine reference missions as shown in Table 2-1. Missions consisting of from 7-13 experiments were formed around each emphasis category. The missions were prioritized in terms of their relevancy to the user needs of the late 1970s and early 1980s so that the highest priority missions could be considered in the computer mission analysis. The assignment of priorities to the first four reference missions was in itself somewhat arbitrary, in that each mission had a high relevancy to the user needs of the late 1970s and early 1980s.

By the seventh priority mission all the Level 1 experiments had been assigned to at least one reference mission (see Figure 2-1). The first four priority missions utilize approximately 80 percent of the Level 1 experiments.

Table 2-1. The Distribution of Level 1 Experiments in Nine Typical Reference Missions

Emphasis Categories	Discipline	Phenomena	Phenomena	Time of Year	Time of Year	Time of Year	Time of Year	Geographical Area	Geographical Area
Level 1 Experiments	Oceanography/Meteorology Priority 3	Pollution Priority 1	Environmental Impact Priority 2	Winter Priority 7	Spring Priority 4	Summer Priority 5	Autumn Priority 8	Low Latitude Priority 6	High Latitude Priority 9
O1	X	X							
O2				X					X
O3					X				
O4				X				X	
O5	X						X		
O6	X						X		
M1						X			X
M2		X				X			
M3	X					X		X	
M4	X	X				X	X		
M5						X	X	X	
M6	X			X					X
AFR1				X	X	X			
AFR2					X		X		
AFR3	X	X	X		X			X	X
AFR4	X		X		X				
G1						X	X	X	
G2		X		X				X	
G3	Zero G (Not applicable to MEO Reference Missions)								
G4		X			X		X	X	X
H1				X	X			X	
H2					X				
H3			X		X			X	
H4	X			X					X
H5				X	X				X
H6	Zero G (Not applicable to MEO Reference Missions)								
E1			X	X	X			X	
E2		X	X			X	X		
E3			X						
OT1						X		X	
OT2		X	X	X	X	X	X	X	
OT3	X	X	X	X	X	X	X		

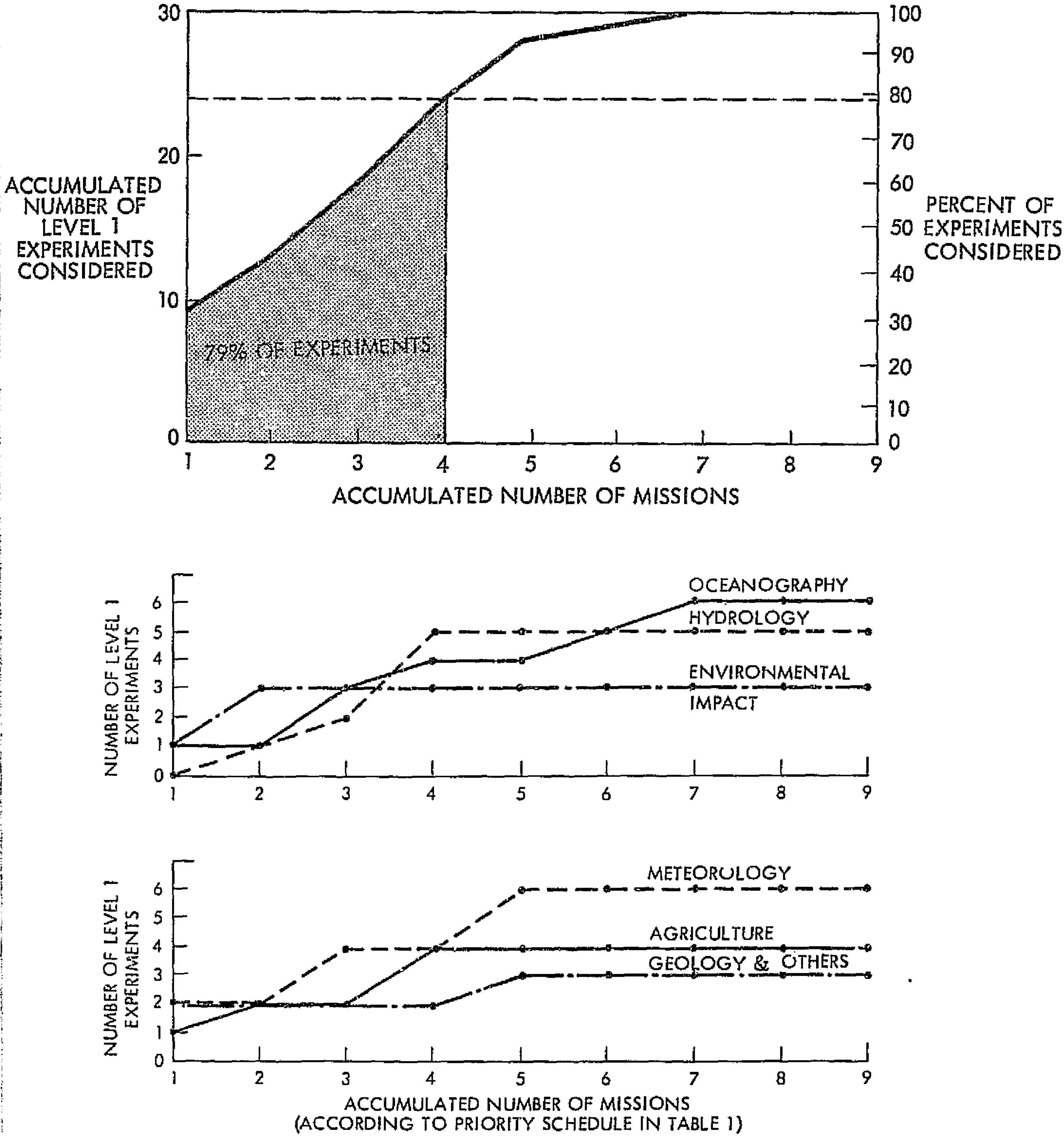

Figure 2-1. Distribution of Level 1 Experiments Among the Prioritized Reference Missions

3.0 MISSION DEFINITION

3.1 INSTRUMENTATION

In Task 1, 54 applications and research experiments addressing a wide cross-section of problems in the earth observations disciplines were identified as potential candidates for early Shuttle Sortie missions. These were documented according to one of three formats. The choice of format documentation reflected each experiment's applicability as a candidate for MEO missions that would be conducted during the first several years of Shuttle Sortie operation, as well as the experiment's applicability to the derivation of mission requirements.

From this group, 30 experiments received the fullest, or Level 1, documentation, including a definition of the measurements and observations required, their temporal and spatial characteristics, and the sensor/instrumentation considered necessary in order to accomplish the experimental objectives according to the proposed technical approach. In order to provide a basis for the development of sensor concepts, the documented measurement requirements were considered from the standpoint of spectral regions, spatial and spectral resolutions, sensitivities, fields of view, areal coverage and frequency of observation. Sensor synthesis was an iterative process, with measurement requirements being tempered by considerations of current and projected state-of-the-art technology and the status of current and projected sensor development. Together with Shuttle and Sortie Lab guidelines and constraints and orbital parameters, these concepts were then used to identify, select and define particular sensor configurations and specifications.

This process, leading to a convergence and consonance of acceptable measurement requirements and achievable sensor performance, resulted in the selection of 33 sensors for use in establishing reference missions and conducting conceptual designs of the MEO. Most of the sensors defined in this manner are probably not precisely those which may be flown in MEO Shuttle Sortie missions; neither are their design specifications likely to remain fixed throughout their development. Nevertheless, they can be considered representative for use in the development of engineering, design and mission requirements.

The subsections that follow provide a broad general discussion of the MEO sensors and their characteristics only insofar as they may impact

on the definition of reference missions and on the development of conceptual designs of the MEO. The discussion begins by indicating how the sensors can be categorized according to a general sensor classification scheme, how they are allocated to each Level 1 experiment, and the relationship of the selected sensors to developments of past, current, and planned programs.

Performance characteristics are discussed in terms of spectral regions used, and the cross-track coverage and spatial resolutions attained, while physical characteristics focus on weight and power values.

Finally, the individual sensor classes are evaluated on the basis of their importance to and their frequency of use by all experiments within each MEO discipline.

3.1.1 MEO Sensors and Sensor Classes

The 33 MEO sensors are listed in Table 3-1. Detailed specifications for each sensor are given in Appendix A. Taken as a whole, they constitute a mix of imaging and non-imaging sensors. Among the former are both photographic (i.e., cameras) and non-photographic (e.g., radars, passive microwave radiometers, ultraviolet, visible, and infrared scanners) sensors. Non-imaging sensors include interferometers, some spectrometers and radiometers, the laser altimeter/scatterometer, sferics receiver, visible radiation polarimeter, and the tracking telescope and wide angle/H-α viewer. (The latter two sensors may accommodate a photographic and a TV camera, respectively.)

The sensors operate over a wide region of the electromagnetic spectrum (see Section 3.1.3), ranging from the UV through the visible, infrared, microwave and the UHF, VHF and HF regions. Horizontal resolution capabilities from an orbital altitude of 200 n. mi. range from 4 meters with the laser altimeter/scatterometer to nearly 1000 km with the sferics receiver (see Section 3.1.3).

Table 3-1. The MEO Sensors

No.	Sensor
1	Tracking Telescope
2	Pointable Identification Camera
3	Panoramic Camera
4	Wide-Angle Framing Camera
5	Multispectral Camera System
6	High Resolution Multispectral Camera System
7	Multiresolution Framing Camera
8	High Resolution Wideband Multispectral Scanner
9	LWIR Spectrometer
10	Wideband Synthetic Aperture Radar
11	Multifrequency Wideband Synthetic Aperture Radar
12	Laser Altimeter/Scatterometer
13	Visible Imaging Spectrometer
14	IR Multispectral Mechanical Scanner
15	High Resolution Visible Imaging Spectrometer
16	High Resolution IR Multispectral Scanner
17	Glitter Framing Camera
18	Star Tracking Telescope
19	UV Upper Atmosphere Sounder (UVUAS)
20	Visible Radiation Polarimeter (VRP)
21	Air Pollution Correlation Spectrometer
22	High Speed Interferometer (HSI)
23	Carbon Monoxide Pollution Experiment (COPE)
24	Cloud Physics Radiometer (CPR)
25	Remote Gas Filter Correlation Analyzer (RGFCA)
26	Advanced Limb Radiance Inversion Radiometer (ALRIR)
27	TIROS-N Advanced Very High Resolution Radiometer (AVHRR)
28	TIROS-N Operational Vertical Sounder (TOVS)
29	Passive Microwave Radiometer (PMMR)
30	Microwave Radiometer/Scatterometer
31	Sferics Receiver
32	Wide Angle Viewer/Hydrogen Alpha Line Viewer
33	Data Collection System

Table 3-2 shows how the Level 1 experiment requirements documented in the study Task 1 report are satisfied with the MEO sensors. It can be seen that a meaningful sensor package for each Level 1 experiment (with the exception of M2) consists of a varied, but selected group of sensors. Several sensors (1, 2 and 32) find essentially universal use by the experiments. The camera systems find the widest use, while a number of the sensors (e.g., 19, 21, 22, 23, 25 and 26) required in experiment M4 are experiment-unique.

Most of the sensors fulfill multidisciplinary requirements, although 15 (or 45 percent) are used in a single discipline only. For example, sensors 15 and 16 (which are high-resolution versions of sensors 13 and 14) are used only in two of the Oceanography experiments. One sensor (the LWIR spectrometer, 9) finds use only in the Geology experiments, while 11 sensors are used only in Meteorological experiments. Of these 11 sensors, one (the star-tracking telescope, 18) is the only sensor required for experiment M2, six find their use only in the experiment dealing with air pollution monitoring (M4), and one (24) is used only in experiment M5 which is concerned with weather modification experiments.

The MEO sensors can be grouped or classed in various ways-- on the basis of their usage by the various experiments, by spectral regions in which they operate, according to their mode of operation (i.e., scanning or not), etc. The grouping shown in Table 3-3 is based on sensor type, and is indicative of the broad range of sensors that have been selected and defined during this study.

3.1.2 Sensor Selection Sources

The MEO sensors can be traced to a variety of sources and programs as shown in Figure 3-1. In many cases, the definition of sensors presents a logical extension of an existing, or soon to be developed, capability. The panoramic camera, for example, has already been successfully flown on the last three Apollo missions and would require only minor modifications for the MEO. Others have already been developed (e.g., for the SKYLAB program), expand on these developments, are currently in various stages of development, or have been proposed for development under other programs such as AAFE, TIROS-N, and EOS, and could be ready for use on early Shuttle Sortie missions. Several

Table 3-2. MEO Sensor Allocation to Level 1 Experiments

Sheet 1 of 2

Experiment ↓ / Sensor →		1 THACKING TELESCOPE	2 POINTABLE IDENTIFICATION CAMERA 70 mm film 11.5 cm. (4.5 in.) f.l. 185 Km (100 n.mi.) coverage 50 m resolution	3 PANORAMIC CAMERA 12 cm. (5 in.) film 60 cm. (24 in.) f.l. 5 m resolution	4 WIDE ANGLE FRAMING CAMERA 24 x 48 cm. (9 x 18 in.) film 30 cm. (12 in.) f.l. 20 m resolution	5 MULTISPECTRAL CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Six cameras (four B&W, color, and false color) 46 cm. (18 in.) f.l., 185 Km (100 n.mi.) coverage 25 m resolution	6 HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film) Six cameras (four B&W, color, and false color) 180 cm. (72 in.) f.l., 11.6 Km. (6.5 n.mi.) coverage 6 m resolution	7 MULTIRESOLUTION FRAMING CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Three cameras, false color film only 46, 92, 184 cm. (18, 36, 72 in.) f.l. 25, 12, 6 m resolution	8 HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER 30/60 m resolution (20 Spectral Bands)	LWIR SPECTROMETER
O1	REGIONAL WATER POLLUTION EXPERIMENT (S. F. Bay)	X	X			X	X			
O2	SEA ICE MAPPING	X	X	X	X					
O3	PLANKTON PROFILING/COASTAL BATHYMETRY MEASUREMENTS	X	X			X				
O4	UPWELLING AREA MAPPING	X	X							
O5	OCEAN WIND AND WAVE EXPERIMENT	X	X	X	X					
O6	SUN GLITTER/MOON GLITTER MEASUREMENTS	X	X							
M1	NOCTILUCENT CLOUD PATROL	X	X							
M2	STELLAR OCCULTATION TO DETERMINE ATMOS. DENSITY									
M3	GLOBAL THUNDERSTORM AND LIGHTNING ACTIVITY	X	X							
M4	AIR POLLUTION MONITORING	X	X							
M5	WEATHER MODIFICATION EXPERIMENTS – TROPICAL STORMS	X	X	X	X					
M6	ICE ON THE SOUTHERN OCEAN	X	X	X	X					
AFR1	INTERNATIONAL AGRICULTURAL EXPER. STATION MON. PROGRAM	X	X			X		X	X	
AFR2	MULTISTAGE SAMPLING OF VEGETATION RESOURCES	X	X	X	X	X		X	X	
AFR3	WILDLIFE – ECOSYSTEM STUDIES	X	X			X		X	X	
AFR4	WINTER DAMAGE ASSESSMENT IN FOREST LAND	X	X	X	X			X		
G1	RAPID GEOLOGIC RECONNAISSANCE MAPPING	X	X	X	X	X		X	X	
G2	COASTAL GEOLOGY AND GEOMORPHIC PROCESSES	X	X	X	X	X		X	X	
G4	GEOLOGIC AND TOPOGRAPHIC MAPPING OF MOUNTAINOUS AREAS OF THE WORLD	X	X	X	X	X		X	X	
H1	GROUND WATER DISCHARGE AND MAPPING	X	X	X	X	X	X		X	
H2	MAPPING GROUND STATE – FROZEN OR NOT	X	X	X	X	X	X	X	X	
H3	SOIL MOISTURE MAPPING TECHNIQUE DEVELOPMENT	X	X	X	X	X	X	X	X	
H4	SNOW AND ICE MONITORING STUDY	X	X	X	X	X			X	
H5	INTERNATIONAL SEASONAL STANDING WATER SURVEY	X	X	X	X					
E1	MONITORING EFFECT OF CHANGING LAND USE PATTERNS ETC.	X	X	X	X	X		X	X	
E2	LAKE EUTROPHICATION, ASSESSMENT OF MAN'S ROLE	X	X			X	X	X	X	
E3	WATER USE PATTERN – IRRIGATION	X	X	X	X	X		X	X	
OT1	ORTHOGRAPHIC MAP CONSTRUCTION FOR DEVELOPING COUNTRIES	X	X	X	X	X		X		
OT2	INTERNATIONAL DEVELOPMENT PROJECT PRE-FEASIBILITY ANALYSIS	X	X	X	X	X		X		
OT3	INTERNATIONAL METROPOLITAN AREA BIENNIAL UPDATE PROGRAM	X	X	X	X			X	X	

FOLDOUT FRAME 1

x x x	x x x	x x x x x	x x x	x x x x	x x x x x	x x x x x x	TRACKING TELESCOPE	1
x x x	x x x	x x x x x	x x x	x x x x	x x x x x	x x x x x x	POINTABLE IDENTIFICATION CAMERA 70 mm film 11.6 cm. (4.5 in.) f.l. 185 Km (100 n.mi.) coverage 50 m resolution	2
x x x	x x	x x x x x	x x x	x x	x x	x x	PANORAMIC CAMERA 12 cm. (5 in.) film 60 cm. (24 in.) f.l. 5 m resolution	3
x x x	x x	x x x x x	x x x	x x	x x	x x	WIDE ANGLE FRAMING CAMERA 24 x 48 cm. (9 x 18 in.) film 30 cm. (12 in.) f.l. 20 m resolution	4
x x	x x x	x x x x	x x x	x x x		x x	MULTISPECTRAL CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Six cameras (four B&W, color, and false color) 46 cm. (18 in.) f.l., 185 Km (100 n.mi.) coverage 25 m resolution	5
	x	x x x				x	HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film) Six cameras (four B&W, color, and false color) 180 cm. (72 in.) f.l., 11.6 Km. (6.5 n.mi.) coverage 6 m resolution	6
x x x	x x x	x x	x x x	x x x x			MULTIRESOLUTION FRAMING CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Three cameras, false color film only 46, 92, 184 cm. (18, 36, 72 in.) f.l. 25, 12, 6 m resolution	7
x	x x x	x x x x	x x x	x x x			HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER 30/60 m resolution (20 Spectral Bands)	8
			x x x				LWIR SPECTROMETER (6.2 - 15.5 μ, 0.4 - 2.4 μ)	9
		x			x	x	WIDEBAND SYNTHETIC APERTURE RADAR (WBSAR) (Wide Coverage, Low Resolution Mode)	10A
		x				x x	WIDEBAND SYNTHETIC APERTURE RADAR (WBSAR) (Medium Coverage, High Resolution Mode)	10B
		x x	x x x				MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (Medium Coverage, Low Resolution Mode)	11A
x	x			x x			MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (Narrow Coverage, High Resolution Mode)	11B
		x	x		x	x x x x	LASER ALTIMETER/SCATTEROMETER	12
	x					x x x	VISIBLE IMAGING SPECTROMETER (Ocean Color Measurement)	13
	x				x x	x x x	IR MULTISPECTRAL MECHANICAL SCANNER (Ocean Surface Temperature Measurement)	14
	x					x x	HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER (Ocean Color Measurement)	15

FOLDOUT FRAME 2

Table 3-2. MEO Sensor Allocation to Level I Experiments

Sheet 2 of 2

Experiment ↓ / Sensor →	16 HIGH RESOLUTION IR MULTISPECTRAL MECHANICAL SCANNER (Ocean Surface Temperature Measurement)	17 GLITTER FRAMING CAMERA	18 STAR TRACKING TELESCOPE	19 UV UPPER ATMOSPHERE SOUNDER (UVUAS)	20 VISIBLE RADIATION POLARIMETER (VRP)	21 AIR POLLUTION CORRELATION SPECTROMETER	22 HIGH SPEED INTERFEROMETER (HSI)	23 CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)	24 CLOUD PHYSICS RADIOMETER (CPR)
O1 REGIONAL WATER POLLUTION EXPERIMENT (S. F. Bay)	X								
O2 SEA ICE MAPPING					X				
O3 PLANKTON PROFILING/COASTAL BATHYMETRY MEASUREMENTS									
O4 UPWELLING AREA MAPPING	X								
O5 OCEAN WIND AND WAVE EXPERIMENT		X							
O6 SUN GLITTER/MOON GLITTER MEASUREMENTS		X							
M1 NOCTILUCENT CLOUD PATROL					X				
M2 STELLAR OCCULTATION TO DETERMINE ATMOS. DENSITY			X						
M3 GLOBAL THUNDERSTORM AND LIGHTNING ACTIVITY									
M4 AIR POLLUTION MONITORING				X	X	X	X	X	
M5 WEATHER MODIFICATION EXPERIMENTS – TROPICAL STORMS									X
M6 ICE ON THE SOUTHERN OCEAN									
AFR1 INTERNATIONAL AGRICULTURAL XPER. STATION MON. PROGRAM									
AFR2 MULTISTAGE SAMPLING OF VEGETATION RESOURCES									
AFR3 WILDLIFE – ECOSYSTEM STUDIES									
AFR4 WINTER DAMAGE ASSESSMENT IN FOREST LAND									
G1 RAPID GEOLOGIC RECONNAISSANCE MAPPING									
G2 COASTAL GEOLOGY AND GEOMORPHIC PROCESSES									
G4 GEOLOGIC AND TOPOGRAPHIC MAPPING OF MOUNTAINOUS AREAS OF THE WORLD									
H1 GROUND WATER DISCHARGE AND MAPPING									
H2 MAPPING GROUND STATE – FROZEN OR NOT									
H3 SOIL MOISTURE MAPPING TECHNIQUE DEVELOPMENT									
H4 SNOW AND ICE MONITORING STUDY					X				
H5 INTERNATIONAL SEASONAL STANDING WATER SURVEY		X							
E1 MONITORING EFFECT OF CHANGING LAND USE PATTERNS ETC.									
E2 LAKE EUTROPHICATION, ASSESSMENT OF MAN'S ROLE	X								
E3 WATER USE PATTERN – IRRIGATION									
OT1 ORTHOGRAPHIC MAP CONSTRUCTION FOR DEVELOPING COUNTRIES									
OT2 INTERNATIONAL DEVELOPMENT PROJECT PRE-FEASIBILITY ANALYSIS									
OT3 INTERNATIONAL METROPOLITAN AREA BIENNIAL UPDATE PROGRAM									

FOLDOUT FRAME

		X				X X	GLITTER FRAMING CAMERA	17
					X		STAR TRACKING TELESCOPE	18
					X		UV UPPER ATMOSPHERE SOUNDER (UVUAS)	19
		X			X X	X	VISIBLE RADIATION POLARIMETER (VRP)	20
					X		AIR POLLUTION CORRELATION SPECTROMETER	21
					X		HIGH SPEED INTERFEROMETER (HSI)	22
					X		CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)	23
					X		CLOUD PHYSICS RADIOMETER (CPR)	24
					X		REMOTE GAS FILTER CORRELATION ANALYZER (RGFCA)	25
					X		ADVANCED LIMB RADIANCE INVERSION RADIOMETER (ALRIR)	26
					X X		TIROS-N ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)	27
					X X X		TIROS-N OPERATIONAL VERTICAL SOUNDER (TOVS)	28
		X X X	X X		X X X	X	PASSIVE MICROWAVE RADIOMETER (PMMR)	29
						X X X	MICROWAVE RADIOMETER/SCATTEROMETER	30
					X X		SFERICS RECEIVER 6 - 20, 300, 610 MHz	31
X X X	X X X	X X X X X	X X X	X X X X	X X X X X	X X X X X X	WIDE ANGLE VIEWER/HYDROGEN ALPHA LINE VIEWER	32
	X X	X X X	X	X	X X X	X X	DATA COLLECTION SYSTEM	33

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Table 3-3. MEO Sensors/Classes

(Numbers in Parenthesis Correspond to List in Table 3-1)

TELESCOPES, VIEWER
- Tracking Telescope (1)
- Star Tracker (18)
- Wide Angle H-α Line Viewer (32)

CAMERAS
- Pointable Identification (2)
- Panoramic (3)
- Wide Angle Framing (4)
- Multispectral (5, 6)
- Multiresolution Framing (7)
- Glitter (17)

MULTISPECTRAL SCANNERS
- High Resolution Wideband (8)
- IR Mechanical (14, 16)

SPECTROMETERS
- Long Wave IR (Also Radiometer) (9)
- Visible Imager (13, 15)
- UV Upper Atmosphere Sounder (19)
- Air Pollution Correlation (21)

SFERICS
- HF, VHF, UHF Receiver (31)

OPTICAL CORRELATION
- Gas Filter Correlation Analyzer (25)

INTERFEROMETERS
- High Speed (22)
- Carbon Monoxide Pollution (23)

RADIOMETERS
- Cloud Physics (24)
- Advanced Limb Radiance Inversion (26)
- TIROS-N Advanced Very High Resolution (27)
- TIROS-N Operational Vertical Sounder (28)
- Passive Multichannel Microwave (29)
- Microwave Radiometer/Scatterometer (30)

RADARS
- Wideband Synthetic Aperture (10A, 10B)
- Multifrequency Wideband Synthetic Aperture (11A, 11B)

LASER
- Altimeter/Scatterometer (12)

POLARIMETER
- Visible Radiation (20)

DATA COLLECTION SYSTEM (33)

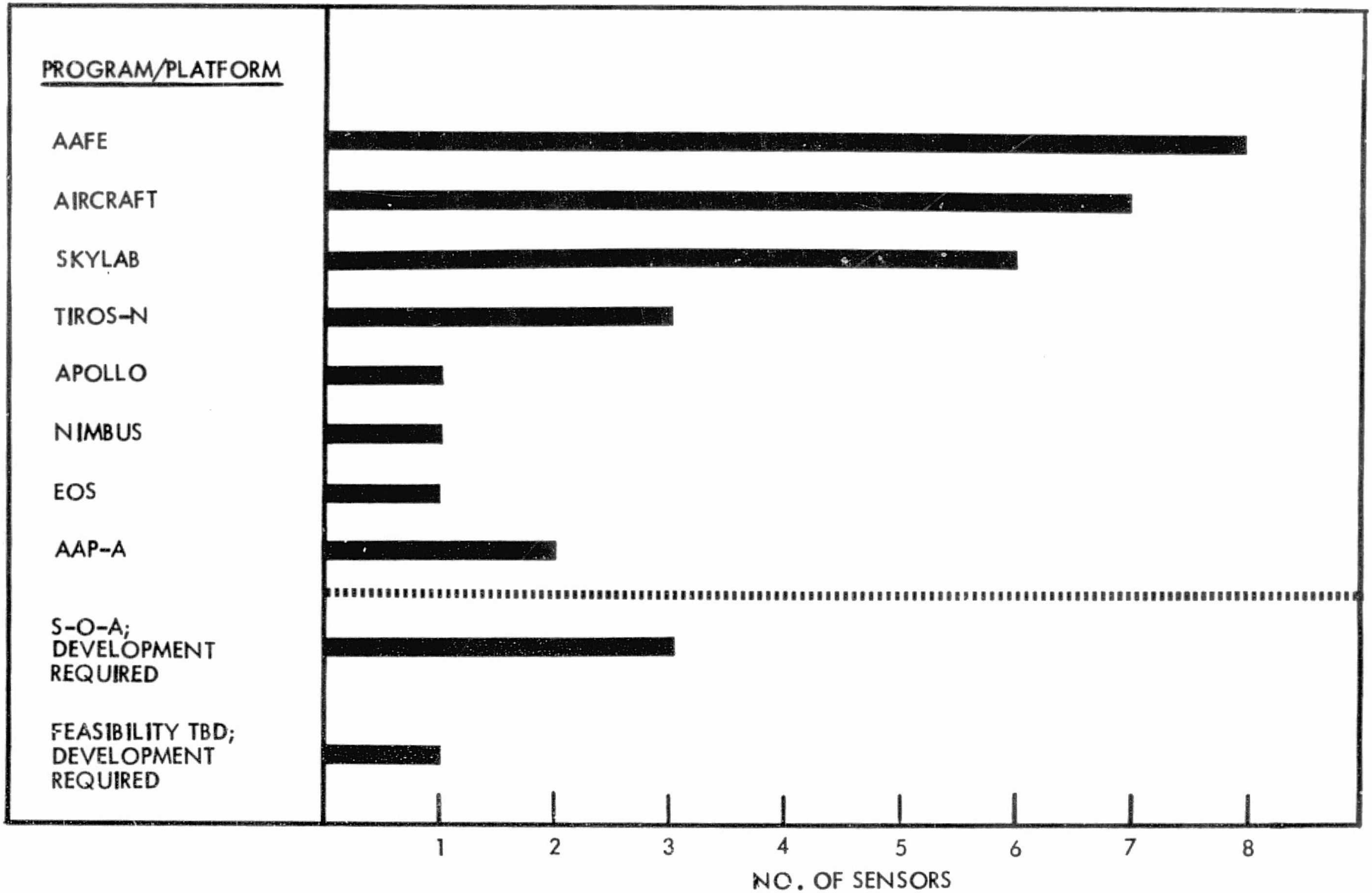


Figure 3-1. MEO Sensor Selection Sources

sensors have their roots in the AAP-A program and their development lies within the state of the art. A number of sensors are defined as extensions of those that have already proven themselves operationally useful in aircraft (e.g., sensors 4, 5, 7, 10, 11, 21, 32). A few sensors (14, 16, 17) are not directly traceable to any particular program; however, their development seems to be within the available state of the art.

Some sensors will require major development in order to bring them to the point where they can be flown on the MEO. Included in this group are the synthetic aperture radars, the passive multichannel microwave radiometer, and the microwave radiometer/scatterometer.

3.1.3 Performance Characteristics

3.1.3.1 Spectral Regions

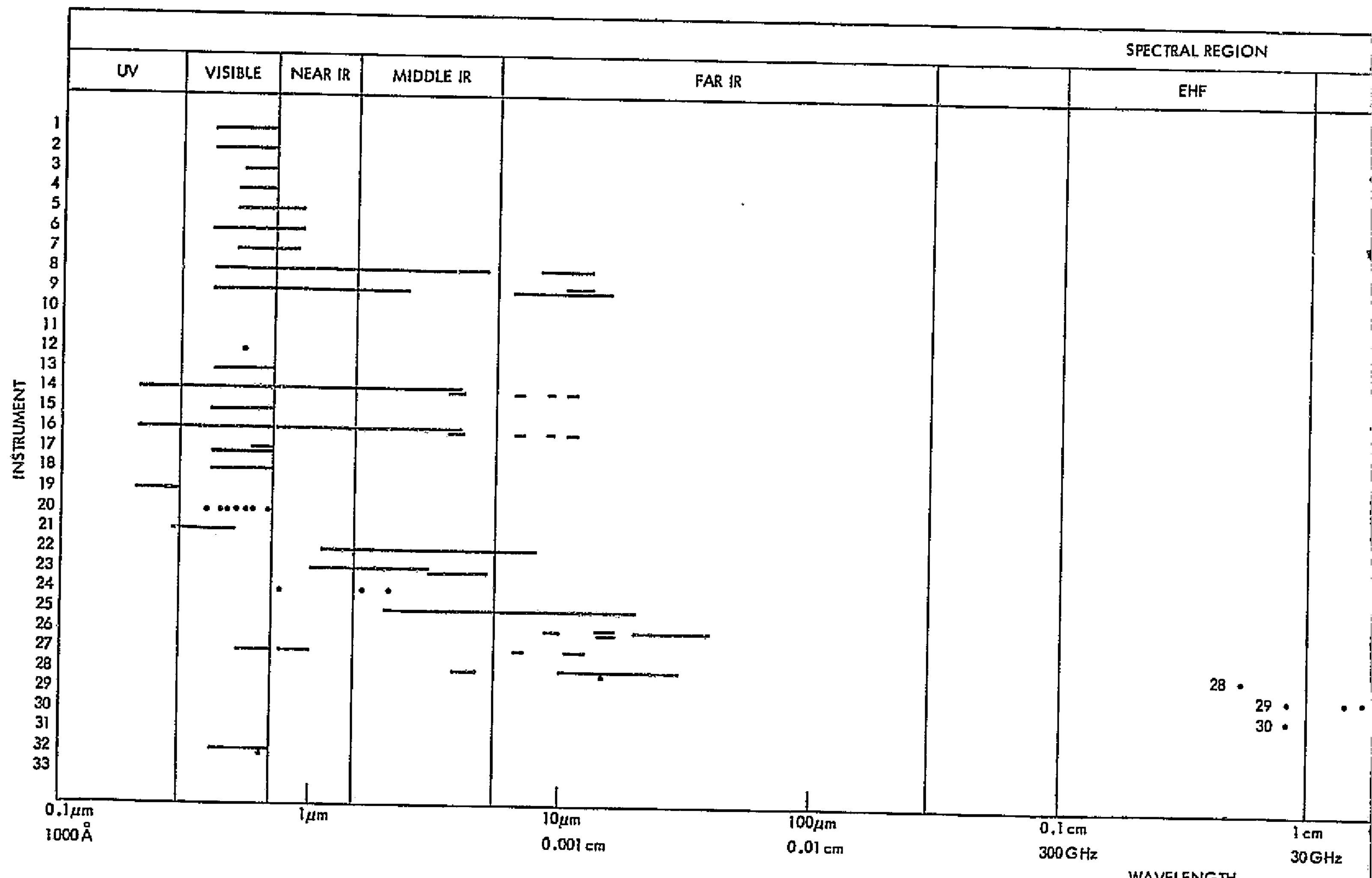
The spectral regions used by each MEO sensor and the corresponding spectral range are shown in Figure 3-2 and 3-3. Taken as a group, they range over eight orders of magnitude from the near-UV to the HF region of the radio spectrum.

In the shorter wavelengths (0.2 - 4 μm), the sensors respond primarily to reflected solar radiation, while in the far-IR and microwave regions the sensors detect upwelling radiation from the earth's surface and the atmosphere (i.e., thermal emission). In the intermediate wavelengths (from approximately 4 - 6μm), both reflected and emitted radiation are detected. Therefore, observations of reflected solar radiation depend on the amount of energy received and reflected by the object being observed, while observations made in the thermal wavelengths are functions of the object's temperature and its emittance. This characteristic, taken together with the nature of the object or phenomena being observed, permits the use of sensors (either singly or in conjunction with one another) which are sensitive to different portions of the electromagnetic spectrum.

Photographic film limits the most common of optical imaging sensors--the cameras--to spectral regions from the near-UV to the near-IR. As a result, these sensors are not operable during nighttime or under very low light level conditions. When clouds, smoke, fog/or haze intervene, "seeing" may be particularly difficult and oftentimes impossible.

NO.	SENSOR	UV	VIS	IR			MICRO WAVE	UHF	VHF	HF
				NEAR	MID	FAR				
1	TRACKING TELESCOPE		●							
2	POINTABLE IDENT CAMERA		●							
3	PAN CAMERA		●							
4	WIDE-ANGLE CAMERA		●							
5	MS CAMERA		●	●						
6	HIGH RES MS CAMERA		●	●						
7	MULTIRES CAMERA		●	●						
8	HIGH RES MS SCANNER		●	●	●	●				
9	LWIR SPECT		●	●	●	●				
10	WIDEBAND SAR						●			
11	MULTIFREQ WIDEBAND SAR						●			
12	LASER ALT/SCAT		●							
13	VIS IMAG SPECT		●							
14	IR MS MECH SCANNER		●	●	●	●				
15	HIGH RES VIS IMAG SPECT		●							
16	HIGH RES IR MS SCANNER		●	●	●	●				
17	GLITTER CAMERA		●							
18	STAR TRACK TELESCOPE		●							
19	UV UPPER ATMOS SOUNDER	●								
20	VIS RAD POLARIMETER		●							
21	AIR POLL CORREL SPECT	●	●							
22	HIGH SPEED INTERFER		●	●	●					
23	CO POLL EXPT		●	●						
24	CLOUD PHYSIC RAD		●	●						
25	GAS FILTER CORREL			●	●					
26	ADV LIMB RAD INVERS RAD					●				
27	TIROS-N ADV VERY HI RES RAD		●	●		●				
28	TIROS-N OPER VERT SOUNDER				●	●	●			
29	PASSIVE MICROWAVE RAD						●			
30	MICROWAVE RAD/SCAT						●			
31	SFERICS RECEIVER							●	●	●
32	WIDE ANGLE/H-- VIEWER		●							
33	DATA COLLECT SYSTEM							● (UPLINK)		

Figure 3-2. MEO Sensors Spectral Region Usage



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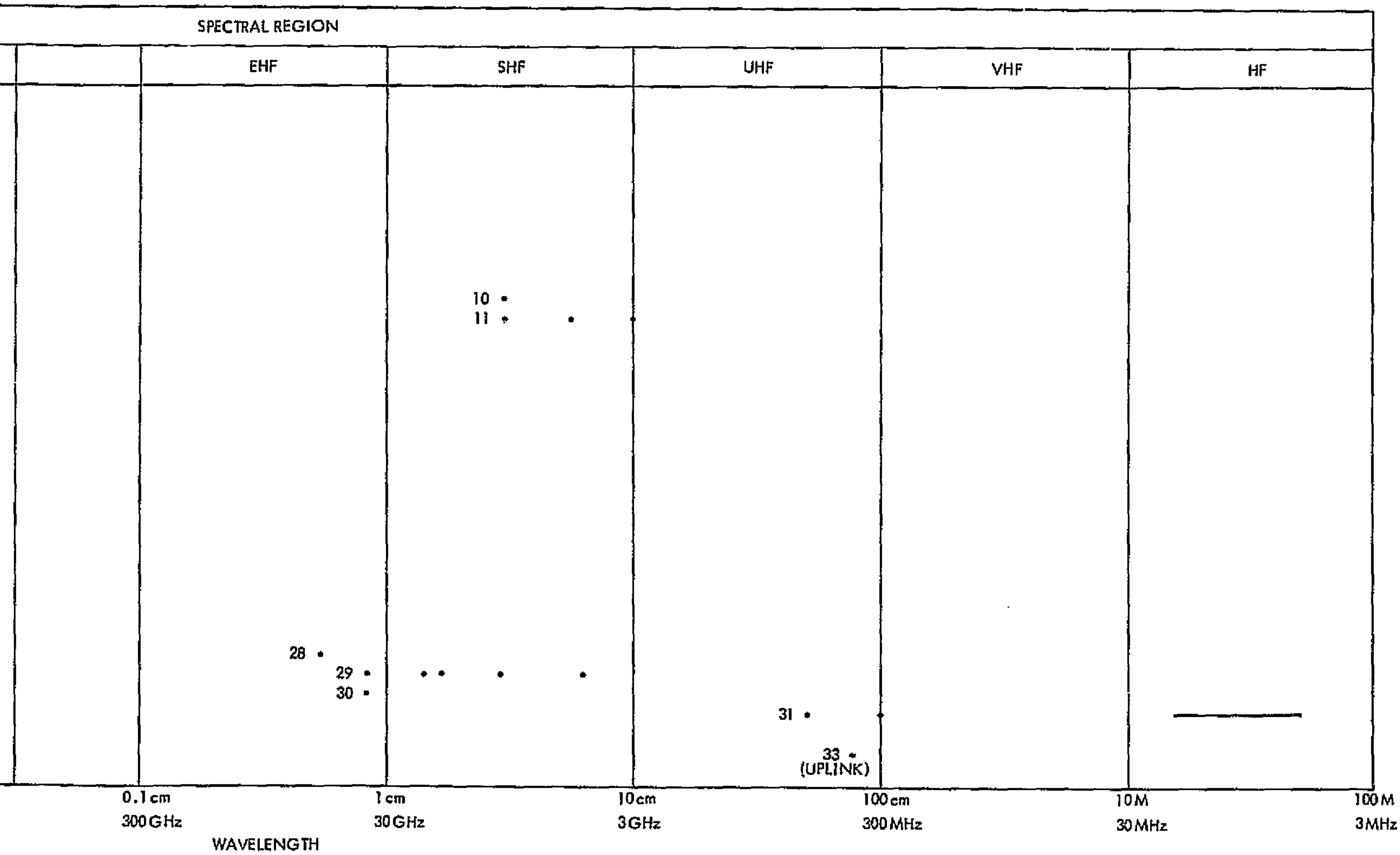


Figure 3-3. Spectral Range of MEO Sensors (Numbers Correspond to List in Table 3-1)

The non-photographic imaging sensors detect reflected and/or emitted radiation from surface features and phenomena or from the atmosphere. They operate in spectral regions which range from the UV to the microwave. The IR, radar, and passive microwave sensors are not restricted to daytime operations and in almost all instances the radars (10 and 11) are not seriously hindered by intervening clouds or precipitation. On the other hand, the passive multichannel microwave radiometer (29) has been configured to detect precipitation as well as to detect surface features in the presence of precipitation.

3.1.3.2 Spatial Resolution

Resolution is an important parameter in describing the performance of earth observations sensor systems. It is measurable, fundamental, and is widely discussed; but its use is difficult and often misunderstood, and its limitations are not generally appreciated.

As used originally by astronomers, "resolution" described the ability of a telescope to separate double stars. As it has come to be applied over the years to photographic systems, resolution refers to the ability of a film or a lens, or a combination of both, to render barely distinguishable a standard pattern consisting of black and white lines. When the resolution of a system is said to be 60 lines (or line pairs) per millimeter, it is meant that the pattern whose line-plus-space width is 0.1 mm is barely resolved, that finer patterns are not resolved and that coarser patterns are more clearly resolved.

Criticism of the use of this single parameter to specify performance is justifiable, for it fails to describe the character of the resolution at all points other than the last, or threshold, value. Nevertheless, it is a convenient measure, useful in making gross comparisons and evaluations.

It is possible to test film and obtain resolution values essentially independent of the lens, and lenses may be visually tested without film. A reliable way to assess the combined effects of film and lens is to use the threshold resolution values of the film and the lens and then add the reciprocals of these values as follows:

$$\frac{1}{R_{F+L}} = \frac{1}{R_F} + \frac{1}{R_L},$$

where R_F and R_L are the resolution in lines per millimeter, of the film and the lens, respectively.

This simple, essentially heuristic, reciprocal formula can be generalized to include terms chargeable to the atmosphere, image motion, film processing and handling, and the like. Thus, more generally, the resolution R_S, of a given system S, is given by

$$\frac{1}{R_S} = \sum_{i=1}^{n} \frac{1}{R_i},$$

where R_i represents the resolution limits of the n separate components.

Ground, or spatial resolution, is a familiar term in all discussions of earth observation sensor performance. It is simply the ground resolution equivalent to one line at the limit of resolution. Thus, if a given system yields R lines per millimeter, and the scale number (the altitude divided by the focal length of the system) is S, the ground resolution (in familiar units and rounding off slightly) is given as:

$$\text{Ground resolution (ft)} = \frac{S}{300R}.$$

Consider the example of the wide-angle framing camera (Sensor No. 4), with a 12-inch focal length lens, viewing vertically at 200 n. mi. The scale number is 1,216,000. At 60 lines per millimeter, the ground resolution would be approximately

$$G = \frac{1,200,00}{300 \times 60} = 67 \text{ ft (20m)}$$

Non-photographic imaging sensors, as well as non-imaging sensors have spatial resolutions determined by their instantaneous field of view (IFOV).

Figure 3-4 shows the horizontal, or ground, resolution provided by the MEO sensors (details are found in Appendix A).

Values for the telescope and viewer are based on observer vision through the sensor eyepiece with a target having an apparent contrast of 2:1.

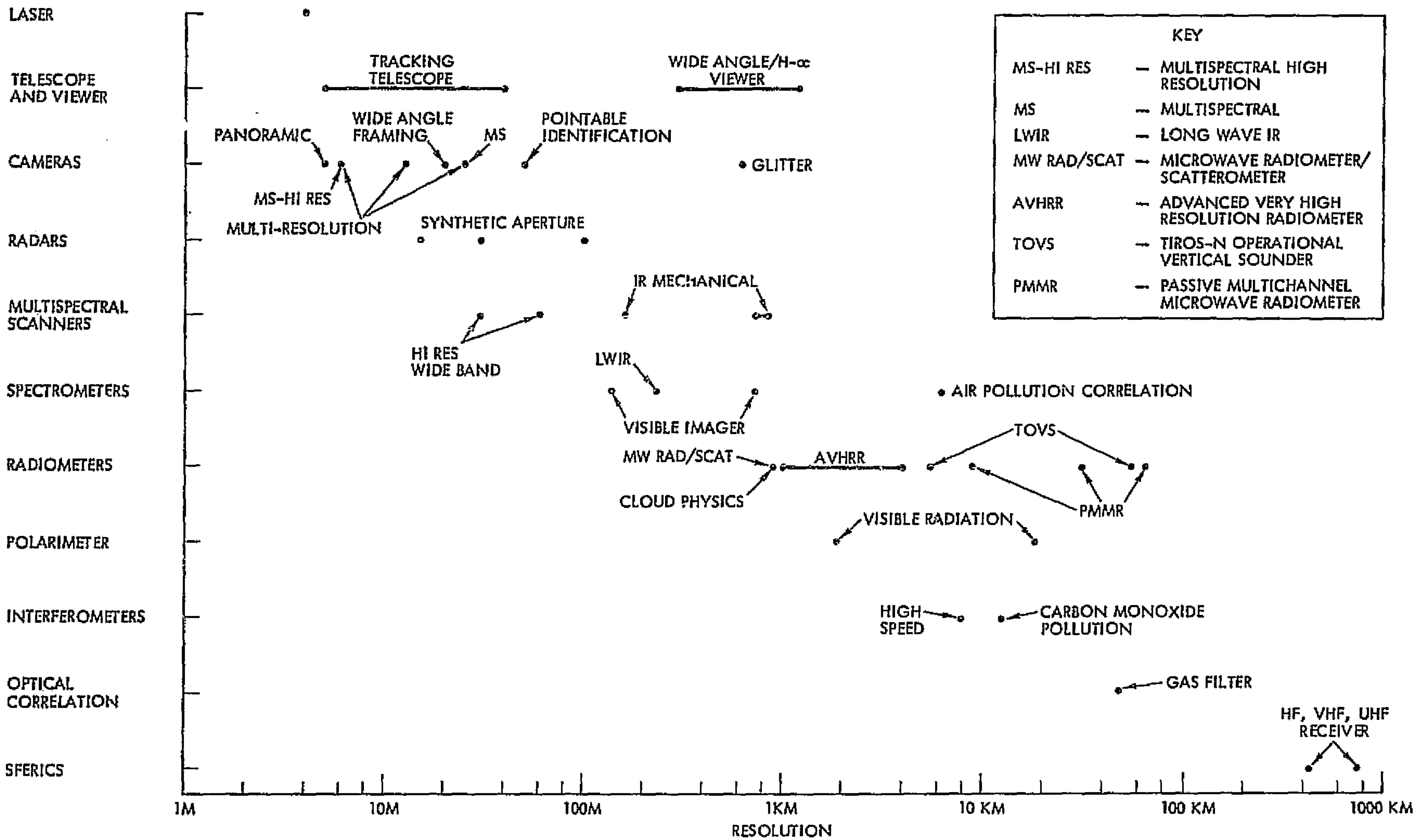


Figure 3-4. Horizontal Resolution Provided by MEO Sensors
(At Nadir and 200 n. mi. Altitude)

The ground resolutions of the high-quality photographic systems are from 5 to 50m, which from an altitude of 200 n. mi. (370 km) corresponds to angular resolutions of from 3 sec to 30 sec. of arc. The air pollution sensors (polarimeter, correlation spectrometer, interferometers, gas filter optical correlation analyzer) have angular resolutions which are typically of the order of tenths of a degree to several degrees.

3.1.3.3 Cross-Track Coverage

The MEO sensors, designed to operate at altitudes specified in the Level 1 experiment requirements documentation, have varying fields of view and viewing angles (see Appendix A). Because of the relatively short duration of the 7-day Shuttle Sortie mission, target availability and target coverage with non-pointing sensors would be minimal. Therefore, in order to increase the amount of useful data on any given orbital pass, most of the sensors have been provided with an off-nadir pointing capability, using either one-axis or two-axis gimballed platforms.

The total angular cross-track coverage provided by the MEO sensors taken as a whole is shown in Figure 3-5. Five sensors provide coverage to more than 60° off-nadir (Note: At a Shuttle altitude of 200 nautical miles, the earth's limb, or horizon, is approximately 71° off-nadir, corresponding to a ground distance from the Shuttle sub-point of approximately 1150 nautical miles), while only two sensors — the laser altimeter/scatterometer, 12, and the carbon monoxide pollution sensor, 23 — provide less than $\pm 15^{\circ}$ off-nadir coverage. Several sensors (19 and 26) utilize the limb — pointing mode, with the sensor pointing towards the earth's horizon, and scanning taking place in the vertical, allowing vertical profile measurements to be made of thermally emitted or solar scattered energy from a narrow region of the atmosphere. The synthetic aperture radars (10 and 11) have fields of view ranging from 8.6° to 14.5°, and look only to one side, either 30° or 56° off-nadir.

3.1.4 Physical Characteristics

Figure 3-6 shows the range and distribution of MEO sensor weights. The multifrequency wideband synthetic aperture radar, 11, weighs 945 kg and the multispectral, 18-inch focal length camera system, 5, (six cameras with 9 in. x 9 in. formats) weighs 760 kg.

When the weight of gimballed platforms required to point individual sensors is added to the sensor weights, the redistribution of MEO sensor weights are as shown in Figure 3-7. The multispectral camera system (5) now becomes the heaviest sensor (1124 kg). Twenty-one, or nearly two-thirds, of the sensors each weigh less than 100 kg, and 45 percent weigh less than 40 kg each.

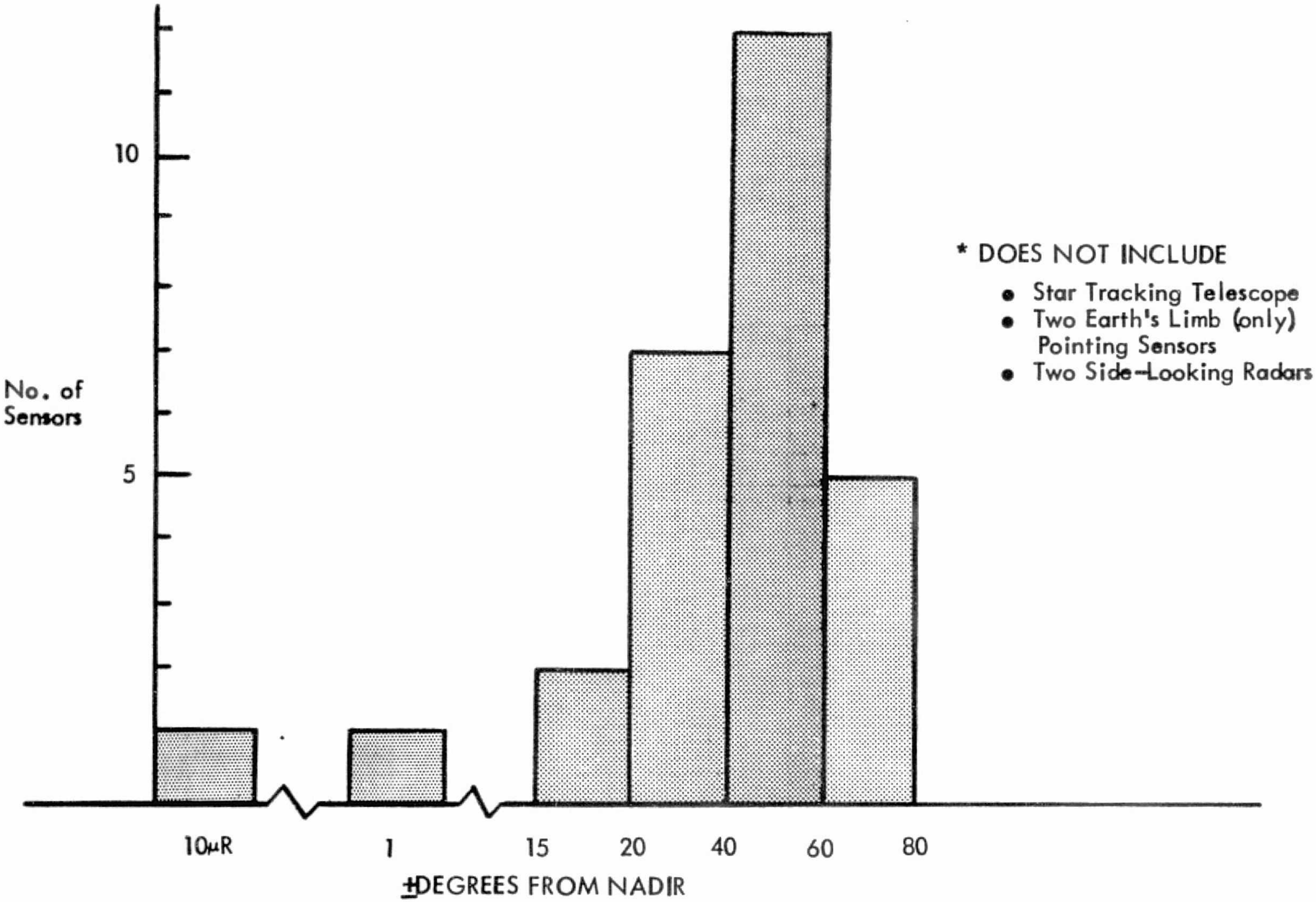


Figure 3-5. Total Angular Cross-Track Coverage*
by MEO Sensors

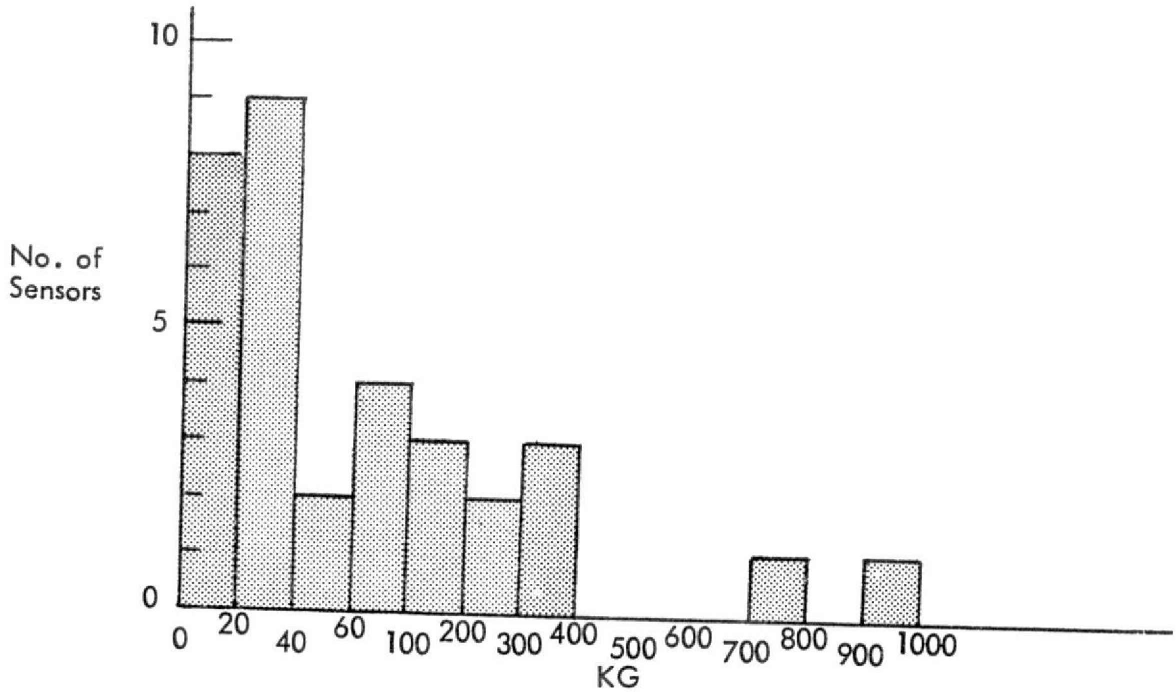


Figure 3-6. MEO Sensor Weights

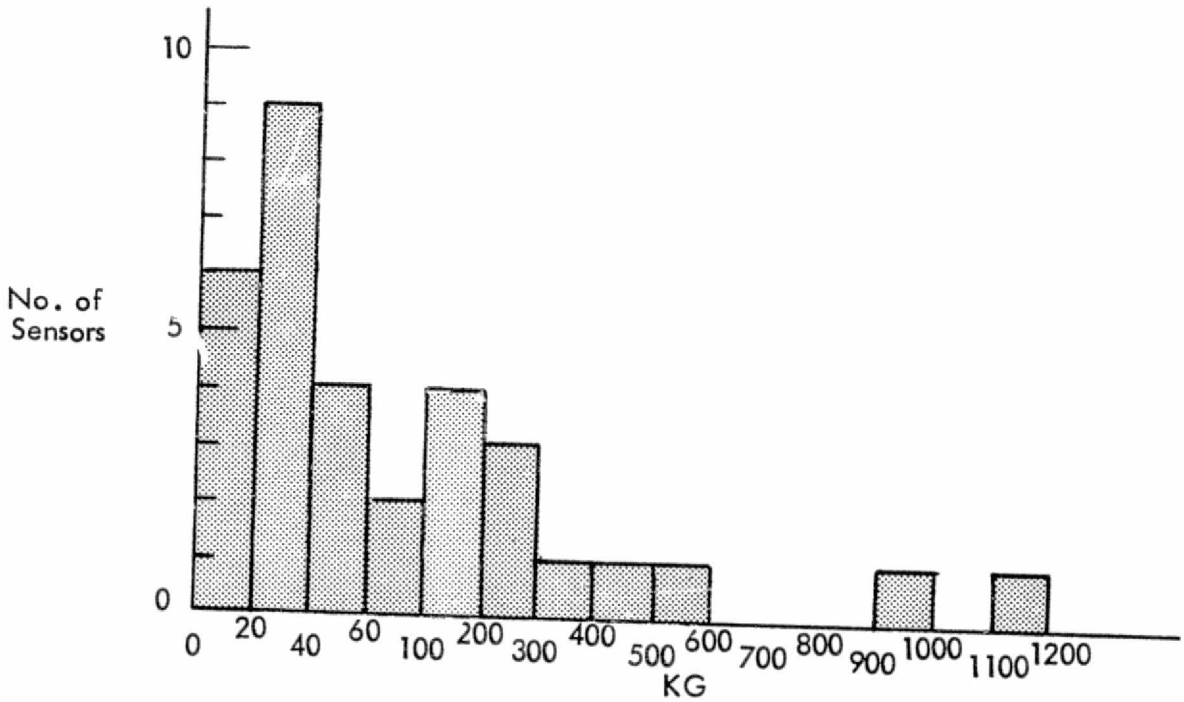


Figure 3-7 MEO Sensor Weights Including Gimbals

Figures 3-8 and 3-9 show the range and distribution of average power used by the MEO sensors, with Figure 3-9 reflecting the increased power chargeable to the sensors that comes with the addition and use of gimballed platforms to point the sensors. More than one-half of the sensors will require less than 100 watts, and almost three-quarters of the sensors will operate with less than 200 watts average power. The multispectral camera system (5) and the synthetic aperture radars (10 and 11) each require approximately 2000 watts. The microwave sensors (29 and 30), the camera systems (3, 4, 7) and the high resolution multispectral scanner (8) each operate at more than 200 watts average power, with the multi-resolution framing camera (7) requiring 1000 watts in the operation of its large format, various focal length system.

3.1.5 Evaluation of Sensor Usage

Figure 3-10 shows how the Level 1 experiments for each earth observation discipline use the various classes of MEO sensors. The number assigned to each box in the matrix is the synthesis of an evaluation based on three separate and mutually exclusive factors, namely:

1) The fraction of experiments (within each discipline) that use some or all of the sensors in a given class

2) The importance of the sensor class to the experiments within a discipline--from the standpoint of obtaining useful and important data

3) The fraction of sensors (making up a sensor class) used by the experiments within each earth observation discipline.

Only the important combinations of these factors have been keyed in order to illustrate the sensor vs experiment usage. The numbers do not constitute a strict rating system, although a 1, with all factors reflecting large fractions and high values, certainly deserves more attention than a 4, with all factors reflecting low fractional usage and lower importance.

Numbers 1 and 3 find wide usage among the experiments in a discipline. Numbers 1 and 2 indicate that a large fraction of the sensor class is used by the experiments in a discipline <u>and</u> that they are of high value to the experiment. Numbers 2 and 4 indicate that the sensor class is used by less than one-half of the experiments in a discipline. Numbers

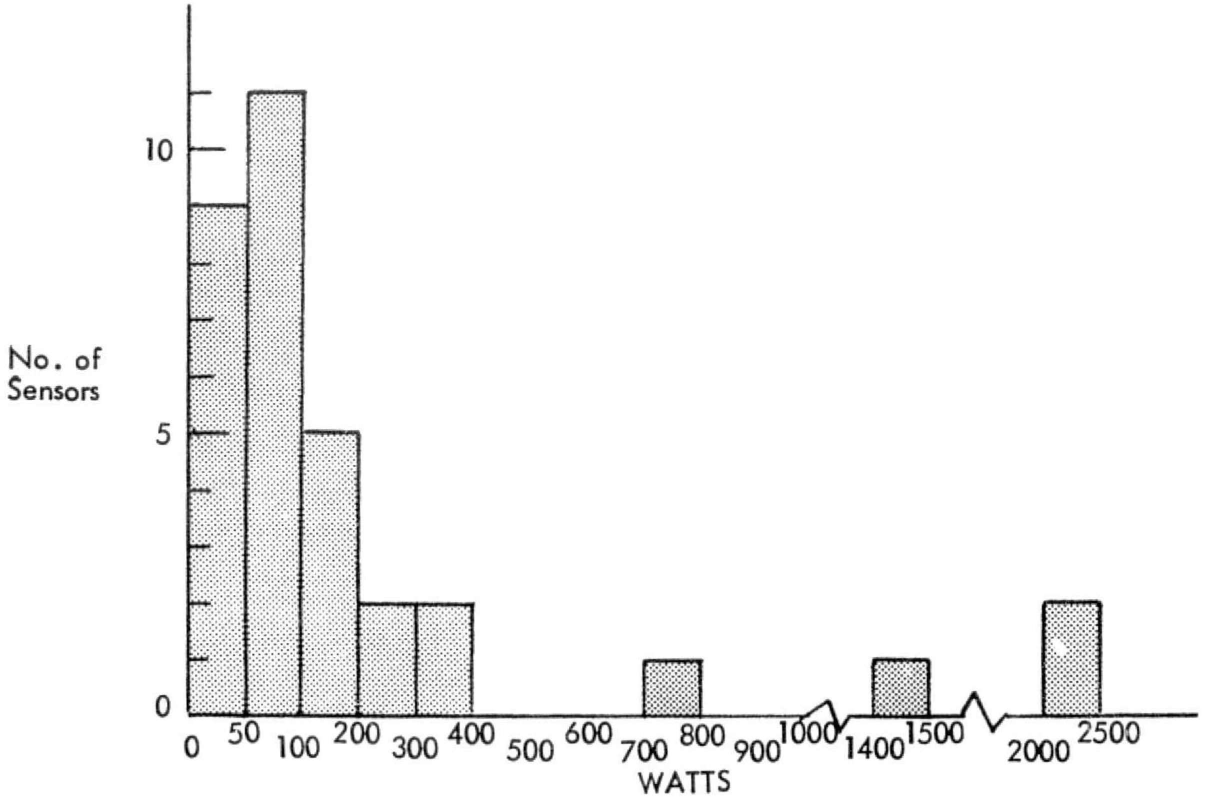


Figure 3-8. Average Power Used by MEO Sensors

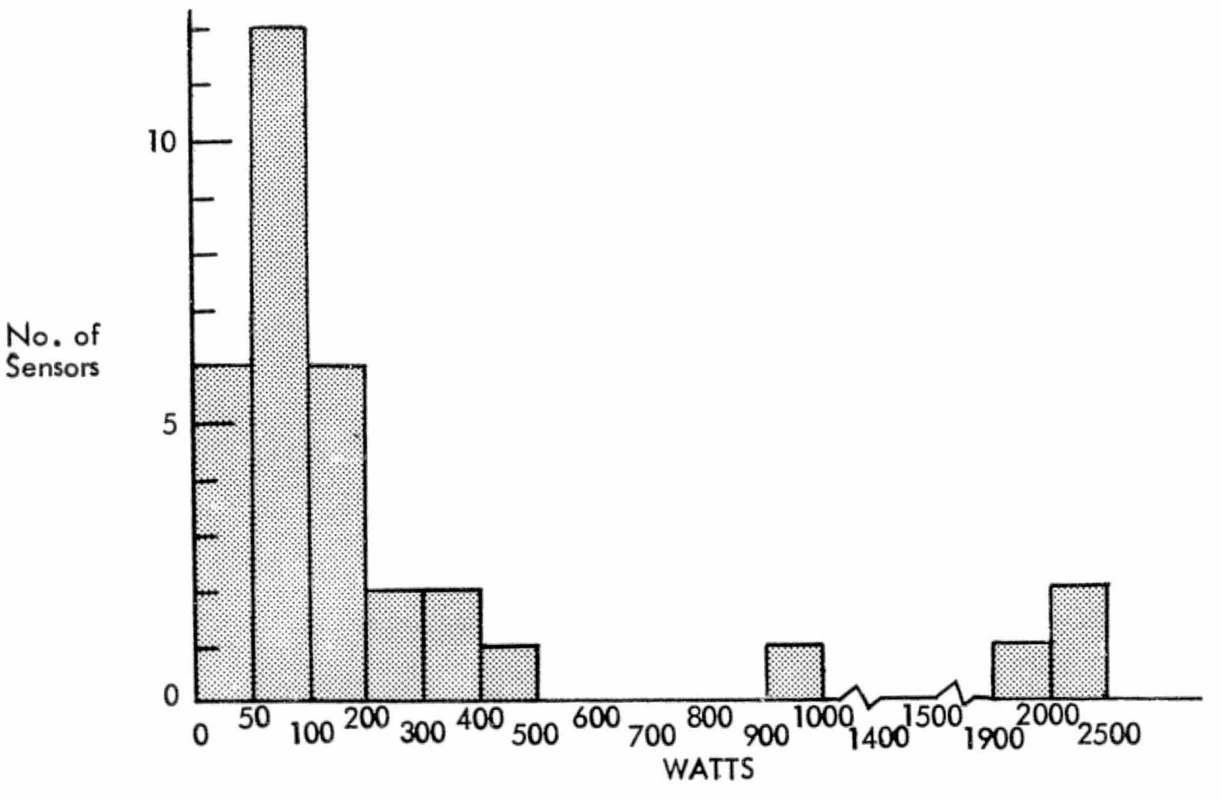


Figure 3-9. Average Power Used by MEO Sensors Including Gimbals

SENSOR CLASS (No. of Sensors in Class) → / EXPERIMENT DISCIPLINES ↓	TELESCOPES/ VIEWER (3)	CAMERAS (7)	MULTISPECTRAL SCANNERS (3)	RADIOMETERS (6)	SPECTROMETERS (5)	INTERFEROMETERS (2)	GAS FILTER CORRELATION (1)	RADARS (2)	LASER (1)	POLARIMETER (1)	SFERICS (1)
OCEANOGRAPHY	1	1	2	4	3			2	1	4	
METEOROLOGY	1	1	4	1	2	2	2	2	4	2	2
AGRICULTURE/ FORESTRY/ RANGELANDS	1	1	1					3			
GEOLOGY	1	1	1	4	1			1	4		
HYDROLOGY	1	1	1	1				1	4	4	
ENVIRONMENTAL IMPACT	1	1	1		2			2			
OTHERS	1	1	4								
NO. OF EXPTS. USING SENSOR CLASS	30	29	19	11	8	1	1	15	7	4	2

Key

1 = Used in ≥50% of expts; high value to expts; large fraction of sensor class used.

2 = Used in <50% of expts; high value to expts; large fraction of sensor class used.

3 = Used in ≥50% of expts; less important to expts; smaller fraction of sensor class used.

4 = Used in <50% of expts; less important to expts; smaller fraction of sensor class used.

Figure 3-10. MEO Experiments and Sensor Usage (30 Experiments, 33 Sensors)

3 and 4 indicate that a smaller fraction of the sensors in a sensor class are used by the experiments in a discipline and that they are of secondary importance to the experiment.

What is definitely indicated by this analysis is that the telescope and wide-angle viewer and most of the camera systems are important to and find universal or near-universal usage by the MEO experiments. Interferometers are used only in a small fraction of the meteorological experiments although they are of high value to the experiment in which they are used. Radars are widely used and important to most of the geology and hydrology experiments.

The number of experiments using one or more sensors from a class of sensors is indicated on the lower line. Again, the visual sensors and the cameras are universally used (if the Stellar Occultation experiment, M2, is for this purpose not included). One or more of the three multispectral scanners are used on almost two-thirds of the experiments, and more than one-third of the experiments make use of one or more of the six radiometers. The meteorological experiments are the only users of the interferometer and the sferics receiver, with the interferometers being used on only one and the sferics receiver on only two of the six experiments documented for this discipline.

3.2 APPLICATION OF COMPUTER PROGRAMS

3.2.1 Introduction

The analysis of reference missions is accomplished by using TRW and MSFC computer programs. These programs include:

MSFC –

- OTO — Orbit Track Optimization
- PACER — Percent Area Coverage, Earth Resources
- AESOP — Automatic Experiment Scheduling and Optimization Program.

TRW –

- ILLUM — Illumination
- RISET — Rise and Set Times (Data Stations)
- CARTOG — Cartography.

The operation and sequencing of these programs is shown in Figure 3-11. Beginning with the reference mission requirements (which included experiment measurement/observation requirements, sensor characteristics and Shuttle Sortie constraints), the high priority reference missions were analyzed using a sequenced set of computer programs to derive the mission requirements for a Manned Earth Observatory.

3.2.2 Program Descriptions

3.2.2.1 Percent Area Coverage, Earth Resources (PACER) Program (MSFC)

The PACER program is used to calculate the percent of a given area covered in a given period of time by an orbiting sensor with a specified field of view. The sensor is assumed to be in a "drag-free" circular orbit with a constant nodal regression rate. The only constraint that may be placed upon the sensor observation is a lighting or illumination constraint which is defined as an upper and lower bound on the solar elevation angle at the subsatellite point.

The program employs a combination of vector mechanics and spherical trigonometry to obtain solutions. The portion of an area that is covered in a specified period of time is calculated by approximate integration.

An evaluation of orbits for earth mapping sensors/missions in which emphasis is placed upon covering as much of a given target area as

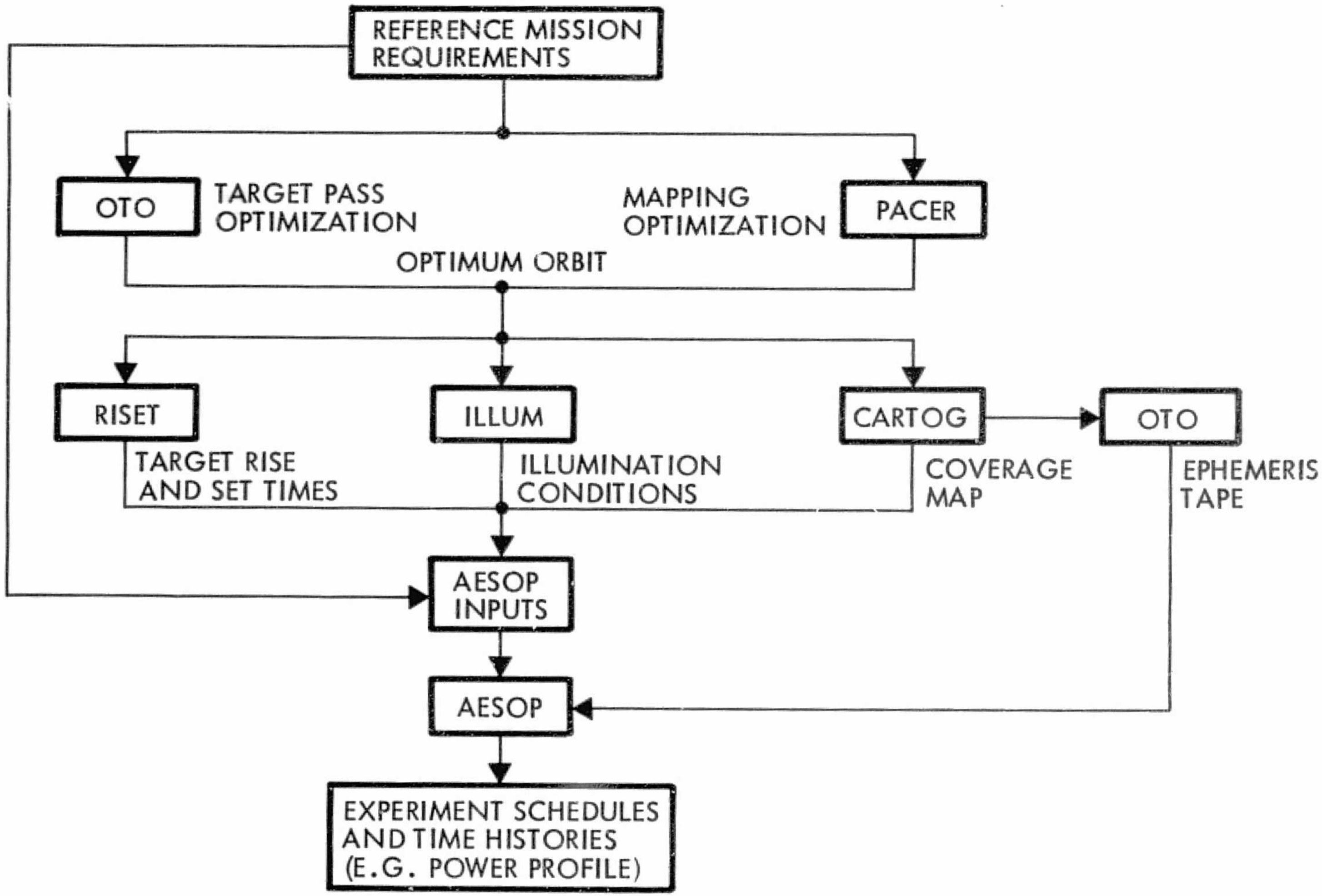


Figure 3-11. Mission Analysis Program Relationships

possible can be accomplished by use of the PACER program. The program can also be used to optimize the orbit altitude, inclination and launch time of day by performing parametric studies.

3.2.2.2 Orbit Track Optimization (OTO) Program (MSFC)

The basic purpose of the OTO program is to determine an optimal orbit for an earth observations mission in which the frequency of target coverage is to be maximized. This is accomplished by determining the altitude, inclination and phasing of an orbit that maximizes the total number of passes over a specified set of targets on the Earth's surface. A target may be anything from a point site to a bounded area, and is input into the program in terms of latitudes and longitudes.

Unlike the PACER program, OTO considers the effect of aerodynamic drag on the number of times the satellite passes over the targets. Nodal regression and the movement of the sun in the ecliptic are included in the simulation. A solar elevation angle constraint can be imposed so that target passes are not counted if the constraint is violated.

Once an orbit is selected, OTO is used to determine the target acquisition and loss times. These times are registered on an ephemeris tape which can be used in scheduling studies.

3.2.2.3 Cartography (CARTOG) Program (TRW)

The purpose of the CARTOG program is to plot charts of the world using the CALCOMP plotters. The charts may be plotted depicting the whole world or subsections thereof. The basic premise behind constructing the program was to allow every option of the program to be completely independent of the other features, thus allowing the program to be completely modular. Additionally, the program was constructed so that the inputs describe a series of overlays to the charts. These overlays may be data developed within the program or constructed by some other program and then overlayed on the chart.

Additional features of this program include:

- Trajectory traces
- Trajectory swaths
- Earth horizon lines

- Tracking Station visibility circles for circular orbits
- Satellite down link antenna footprints
- Lines of constant range contours
- Lines of constant latitude and longitude emanating from an arbitrary point
- Trajectory traces generated by external programs.

The projections available are:

- Cylindrical family
  - Uniform grid
  - Mercator
- Conic family
  - Lambert conformal
  - Gonigraphic
  - Transverse mercator
  - Oblique mercator
- Azimuthal family
  - Azimuthal equidistant
  - Azimuthal equidistant sector
  - Stereographic
  - Orthographic
- Kepler double map.

3.2.2.4 Illumination (ILLUM) Program

This program plots the solar illumination angle as a function of days from vernal equinox for a variety of latitudes. It informs the user of those geographical areas that have acceptable sun angles for the sensors being considered. The portion of an orbit with acceptable sun angles can therefore be plotted over the entire coverage cycle.

3.2.2.5 Data Station Rise and Set Times (RISET) Program (TRW)

RISET is a Fortran program developed for use on the CDC 6500 Computer to generate a rise (acquisition) and set (loss) time history for a specified orbit, ground station network and elevation angle. The output may be printed and/or plotted on Calcomp Plotters. The printed output is a history of station rise and set times and the duration of the observation time per orbit revolution. The plotted output is a graph of the printed output of station vs time and station review.

As an additional option, CARTOG may be used to generate a plot time history of the station rise and set times for the mission orbit and data station network over a selected projection of the earth.

3.2.2.6 Automatic Experiment Scheduling and Optimization Program (AESOP) (MSFC)

AESOP generates a prescribed number of feasible experiment/sensor schedules along with the total requirements of specified parameters including electrical power, data requirements, etc. A time history of resource utilization is simultaneously generated with each schedule and specific resource requirements (e.g., average electrical power) are automatically summarized with appropriate histograms and time histories.

Fundamental to the operation of AESOP is the understanding of several terms.

- Experiment — An activity involving one or more sensors dedicated to one application (e.g., air pollution monitoring)
- Event — A sensor activity with constant resource and constraint requirements (e.g., set up, operate, and calibrate)
- Constraint Requirements — Nondepletable factors which limit the time interval available for an event (e.g., illumination conditions and tracking station visibility)
- Resource Requirements — Items which may or may not be depletable. A skill requirement is depleted only if demand exceeds availability and even then, only as long as the demand exists. Film, on the other hand, is available in a fixed quantity and cannot be reused; therefore, it is depletable.

AESOP is composed of three main sections. Section I initiates the scheduling process by merging the ephemeris requirements (targets, lighting, etc.) for each sensor event with the start/stop times for ephemeris conditions derived for the mission by the OTO Program. The output of this section is the initial candidate interval timeline. Section II merges the event resource requirements and resource availability with the stop/start times of event resource availability. It also merges the initial candidate interval timeline with the resource availability timeline and eliminates intervals where resources are not available. The resulting start/

stop times are the final event candidate intervals. In Section III a random search is conducted using a Monte-Carlo technique to order the schedule and select the start time for each event. Included in this search are the following considerations:

- Event priority ordering requirement
- Repeat performance requirements
- Precedent requirements.

This process is reiterated until all events have been scheduled.

In terms of mission planning, the program has a variety of uses:

- N feasible schedules can be computed and compared
- The interdependence of schedule parameters
- The effect of weighted parameters on the schedule
- Mission support requirements
- Mission compatible experiments.

3.2.3 Program Application

3.2.3.1 Orbital Optimization Programs (OTO and PACER)

The selection of an orbit for a MEO reference mission was governed by the requirements of the mission experiments:

- Target locations and sites
- Observation frequencies desired/acceptable
- Altitude range desired/acceptable
- Illumination considerations
- Coverage requirements

The target locations and sites were specified in terms of latitude and longitude ranges (areas were defined using rectangles). Observation frequencies were expressed as the desirable and acceptable number of looks or sightings per day. The desirable and acceptable altitude ranges were expressed in nautical miles. The illumination constraints were specified in terms of solar elevation angle and time of year. The final specification was which program should be used. The experiment inputs are in Appendix B.

In addition to the orbital selection constraints imposed by the requirements of the mission experiments, only circular orbits were considered, and mapping and high frequency coverage could not be simultaneously considered.

As shown in Figure 1-1, only the first four reference missions were carried through an orbital analysis. Since all the experiments within each of the four missions had a strong frequency of coverage requirement (1 look/2 days), OTO was used to select the mission orbits. The results are depicted in Figure 3-12. Reference missions 1, 2, and 4 are similar in a number of ways:

- Moderate to low latitude targets resulted in inclinations between 40 and 50 degrees and an altitude of approximately 180 nautical miles.
- Each mission could be flown from an ETR launch (inclination $< 59^{o}$).

The Oceanography/Meteorology Reference Mission (Priority Number 3) varied somewhat from the others in terms of orbital parameters because

INPUT

- TARGET AREA/LOCATION
- OBSERVATION FREQUENCY
- ALTITUDE RANGE
- ILLUMINATION CONSTRAINTS
- OPTIMIZATION:
  MAPPING
  FREQUENCY

CARRIED THROUGH EXPERIMENT SCHEDULING AND FACILITY DESIGN

* MISSION PRIORITIES

OUTPUT

PARAMETER \ REF MISSION	POLLUTION 1*	ENVIR IMPACT 2*	OCEAN./MET 3*	SPRING 4*
ALTITUDE (N MI)	183	183	199	180
INCLINATION (DEG)	48	48	70	43
INITIAL RIGHT ASCENSION OF ASCENDING NODE (DEG WEST)	118	107	134	113
NODAL PERIOD (MIN)	91.2	91.2	91.2	91.1
CYCLIC FREQUENCY (DAYS)	2	2	2	2
LAUNCH SITE	ETR	ETR	WTR	ETR

Figure 3-12. The Results of the Orbital Optimization

of a strong requirement to cover the 68° - 72° latitudinal belt every two days in the Ice in the Southern Ocean experiment (see Volume 1 and Appendix B, Experiment M6). This requirement necessitated a WTR launch, an inclination of 70° and an altitude of 199 nautical miles.

To meet the illumination requirements and target phasing the right ascension of the ascending node ranged from 107-134° West.

3.2.3.2 Orbit Evaluation Using the CARTOG, ILLUM and RISET Programs

Since the first priority reference mission, pollution, was to be carried through experiment scheduling, its orbit was subjected to a re-evaluation using the CARTOG, ILLUM and RISET computer programs.

Assuming that it takes one day for the Shuttle Orbiter to reach an operational orbit position and one day to shut down the experiments and return to the earth, there are five days in a Shuttle Sortie flight to complete a reference mission. The CARTOG program was used to plot a five day trajectory subsatellite time history on a specified projection of the earth. (See Figures 3-13 through 3-17). An enlargement of the Continental United States is shown in Figure 3-18, to illustrate the sizes and distribution of pollution mission targets. These coverage plots were used to determine if there were any additional targets that were covered by the selected orbit and should be considered in the mission. The study team disciplinarians decided that no additional targets should be added to the mission.

The ILLUM program was used to re-evaluate the sun elevation angle constraints on the experiment targets. For a launch date of May 4 and an initial right ascension of the ascending node of 118° all the northern latitudes (and therefore all the mission targets) have a sun angle greater than or equal to 30° which satisfies the initial constraint.

Using the Manned Spaceflight Network (MSFN) as ground stations and assuming a 10° readout circle, the pollution mission was evaluated in terms of the frequency and duration of possible data dumps. This was accomplished through the use RISET and CARTOG. RISET was used to generate an acquisition and loss timeline and CARTOG was used to plot the time history. As shown in Figure 3-19, 2-minute trajectory tick marks were used to indicate time and a 10° readout circle was plotted

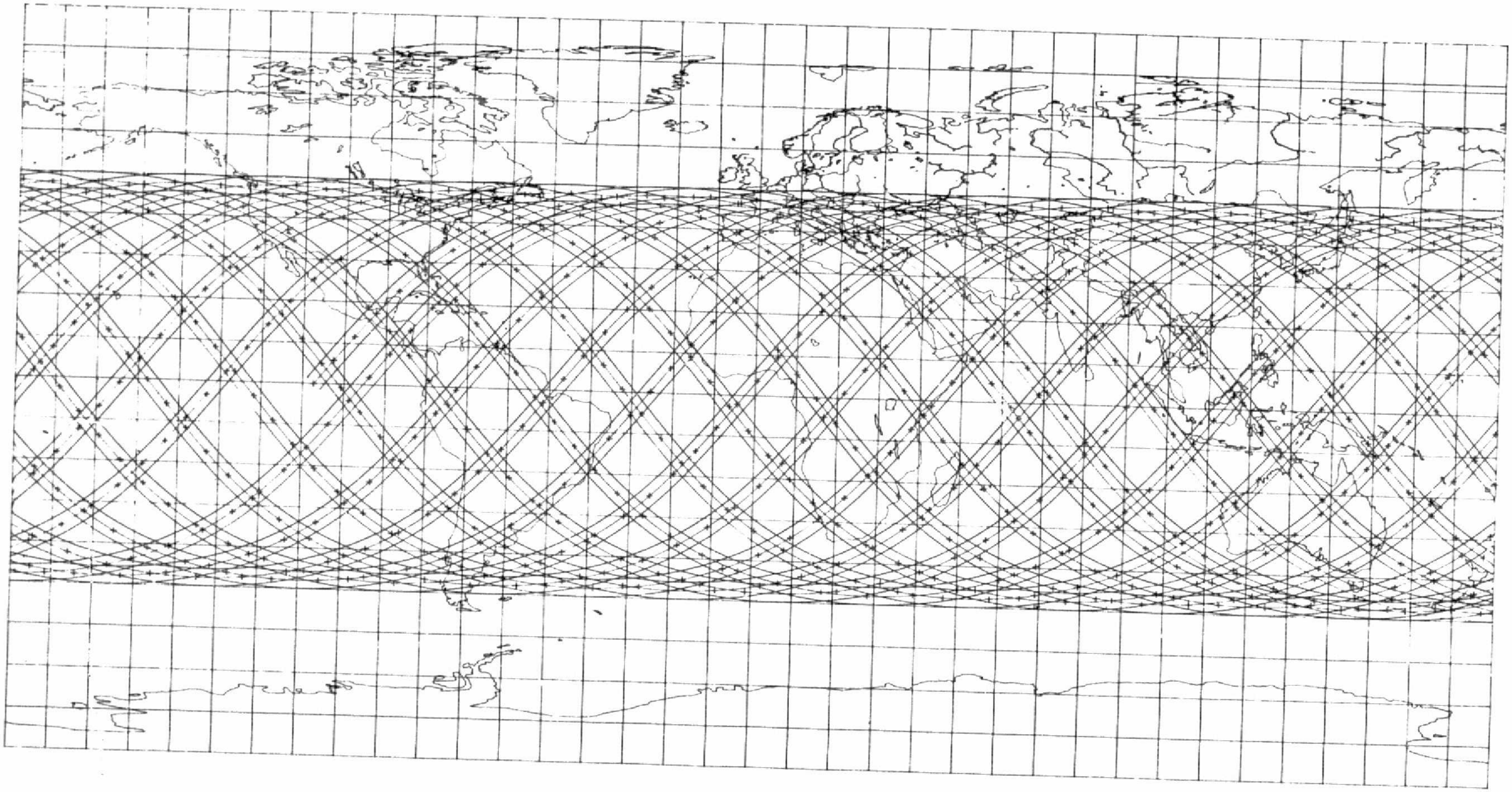


Figure 3-13. First Day's Ground Trace Pattern for the Pollution Reference Mission--Evaluated for Additional Targets

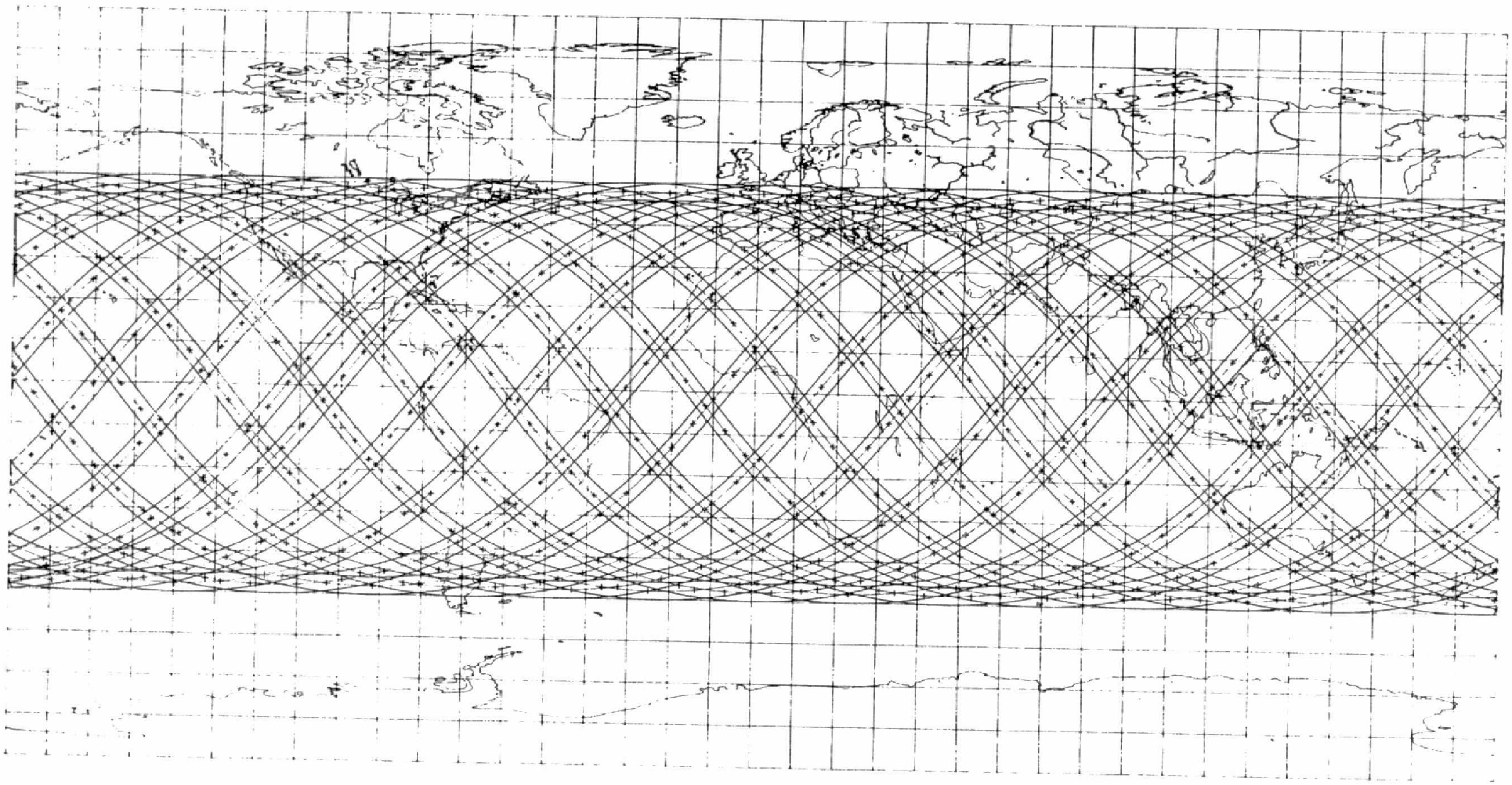


Figure 3-14. Second Day's Ground Trace Pattern for the Pollution Reference Mission--Evaluated for Additional Targets

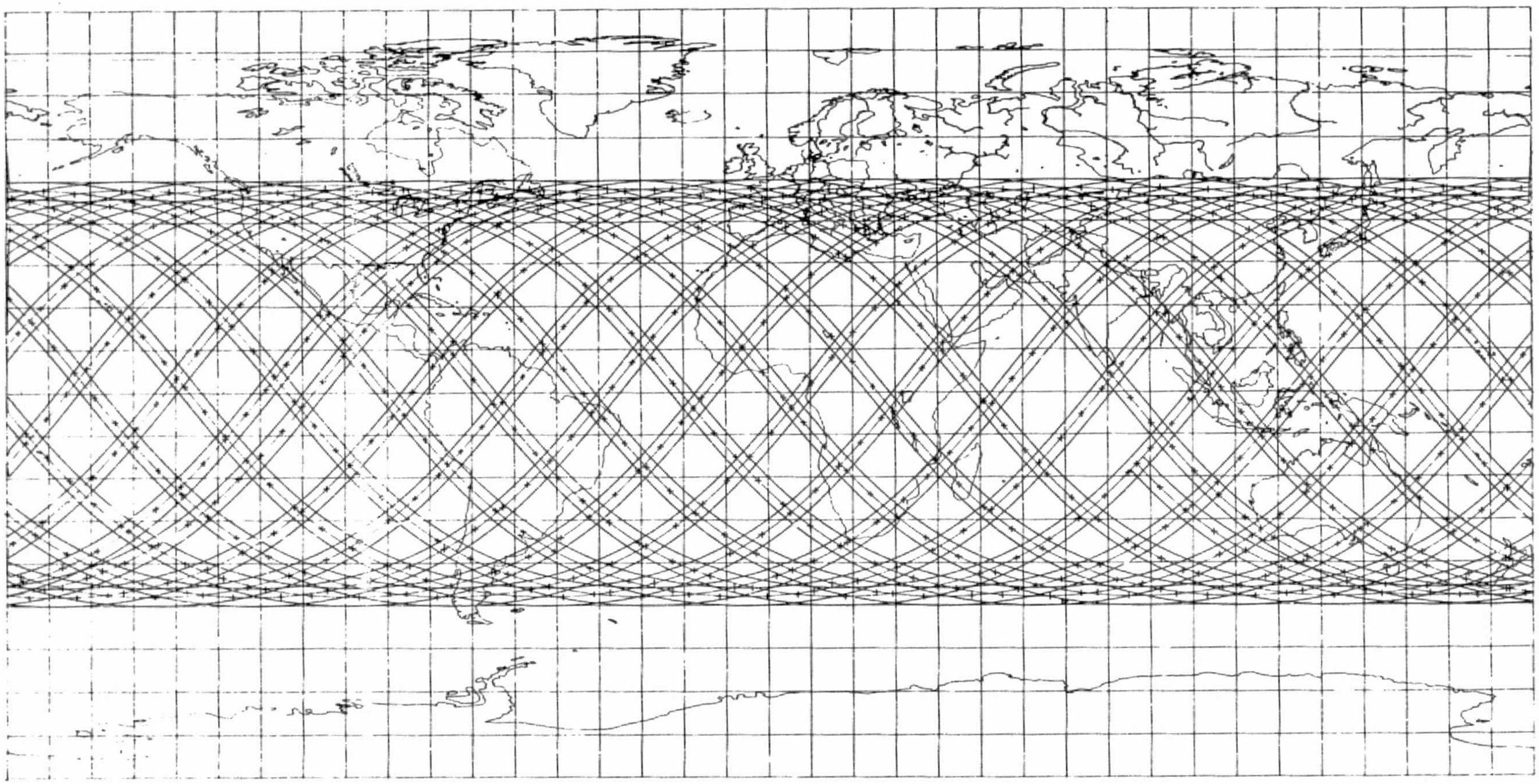


Figure 3-15. Third Day's Ground Trace Pattern for the Pollution Reference Mission--Evaluated for Additional Targets

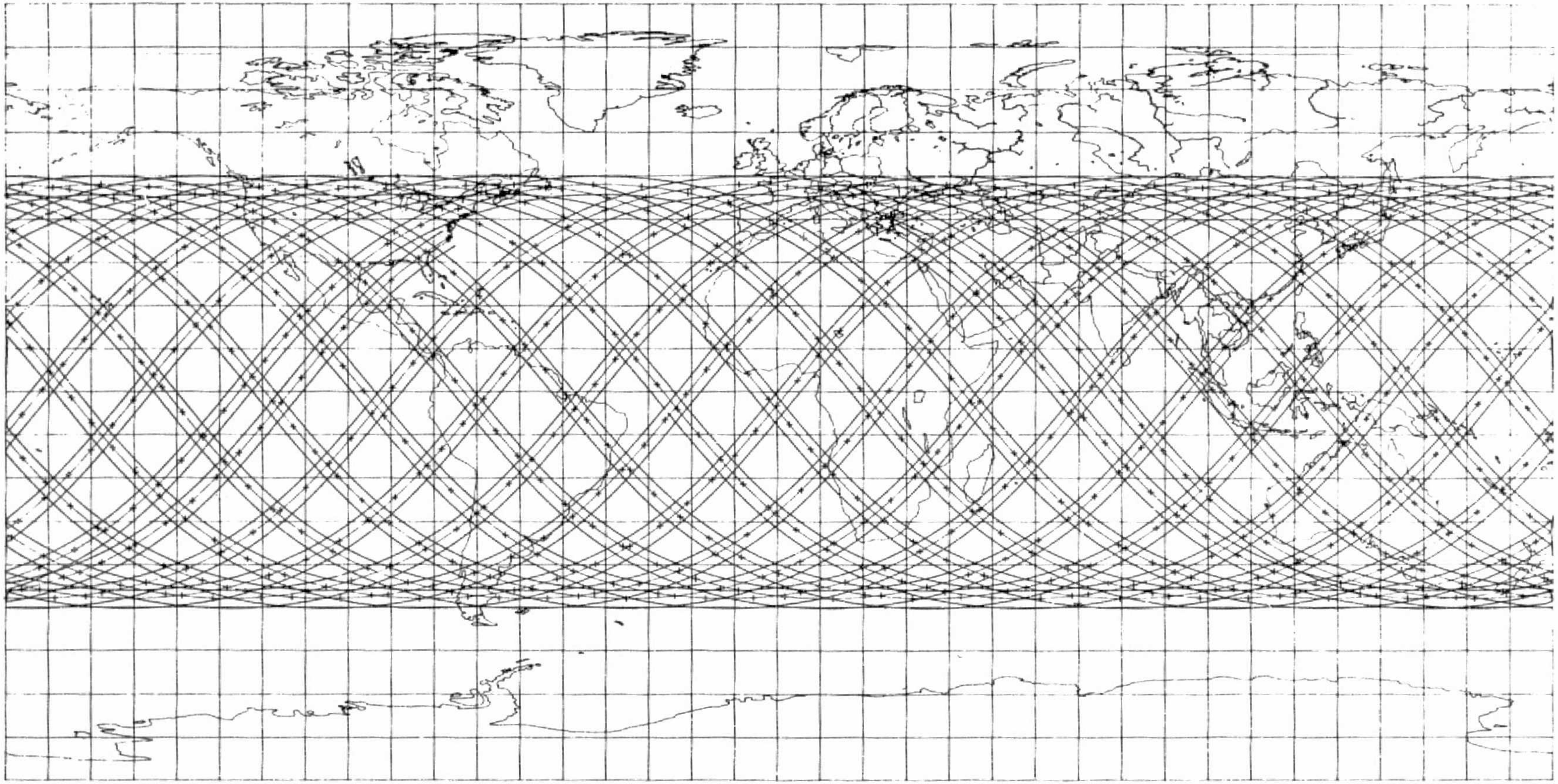


Figure 3-16. Fourth Day's Ground Trace Pattern for the Pollution Reference Mission--Evaluated for Additional Targets

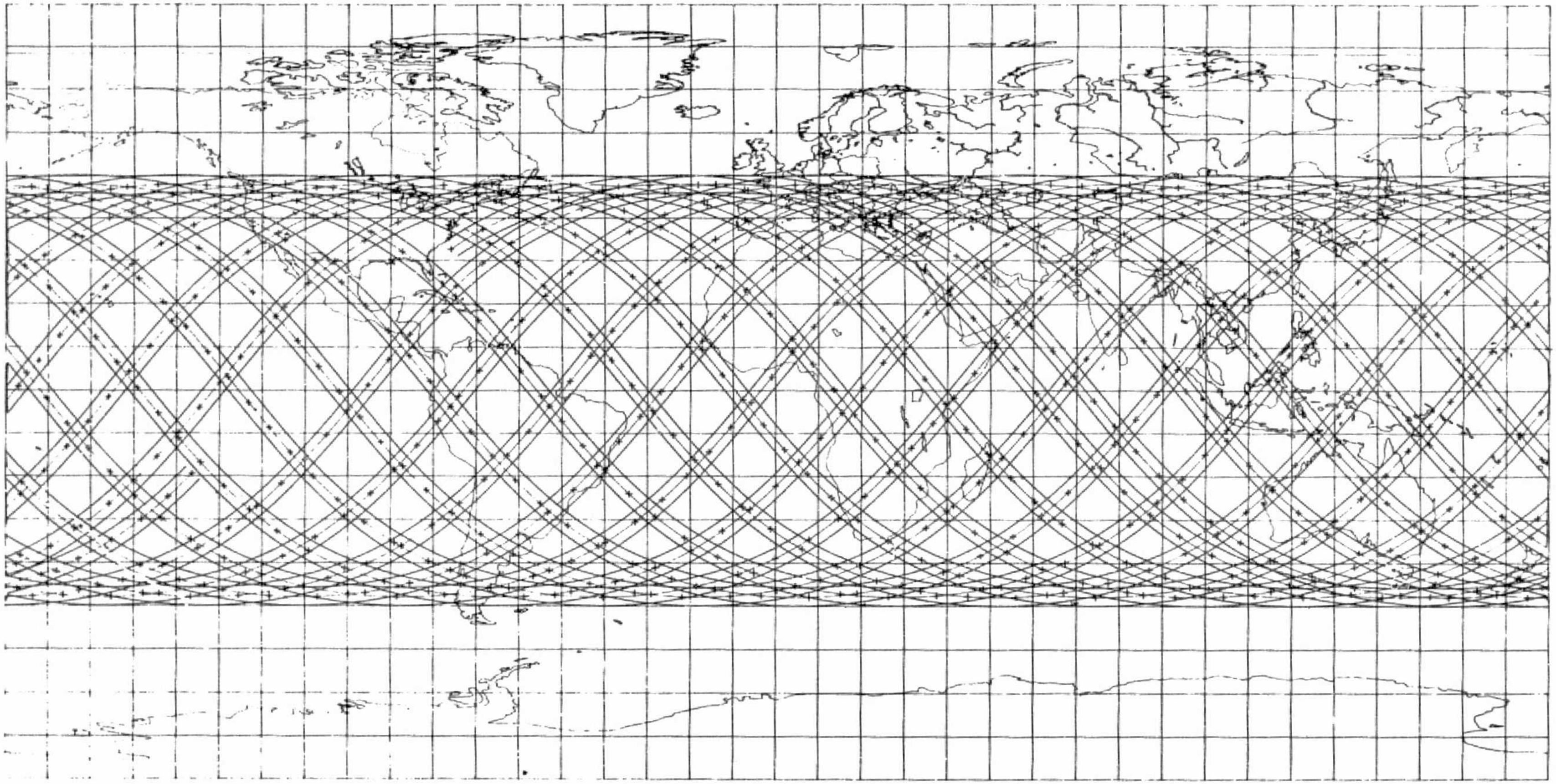


Figure 3-17. Fifth Day's Ground Trace Pattern for the Pollution Reference Mission--Evaluated for Additional Targets

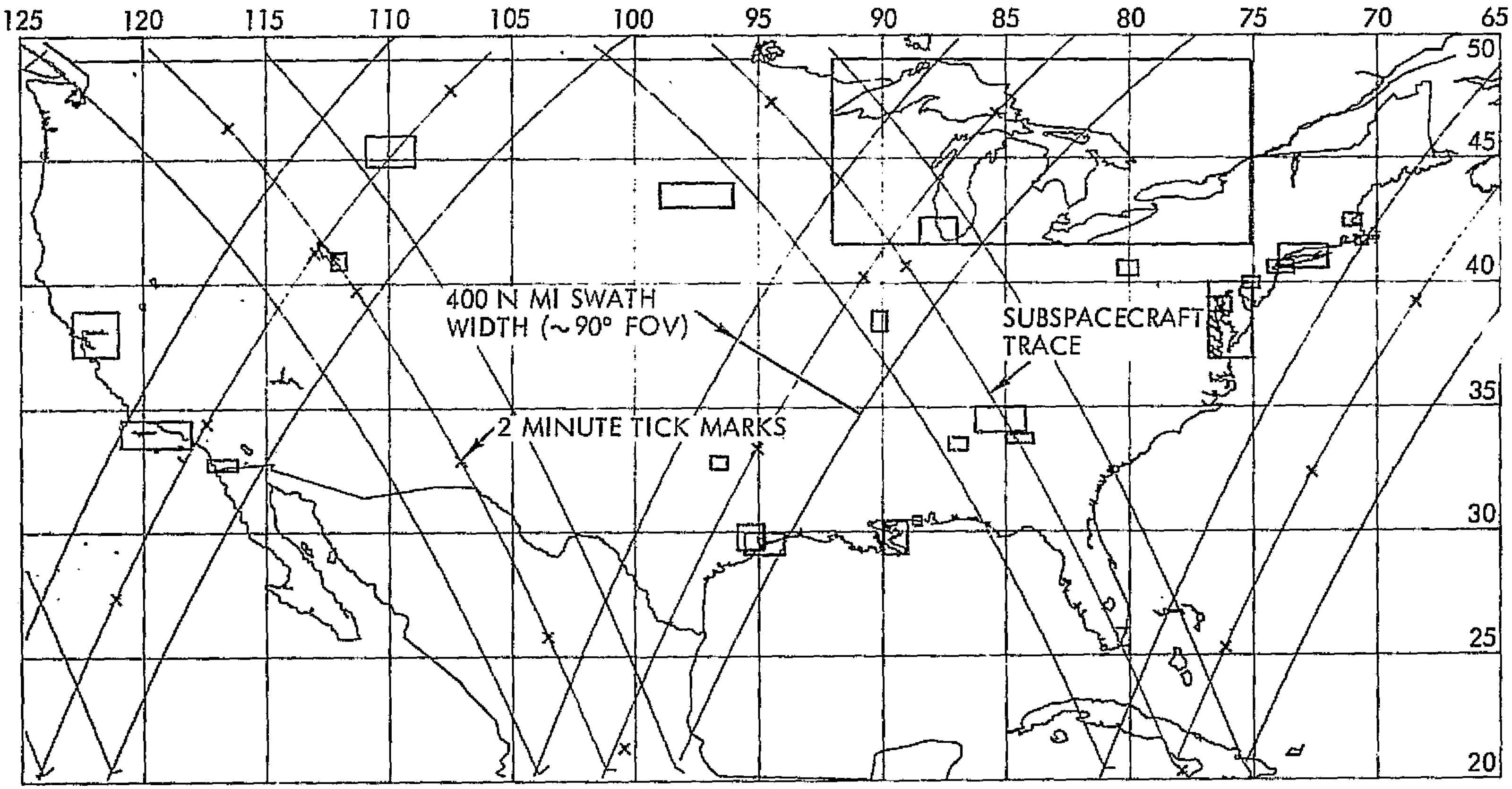


Figure 3-18. A U.S. CARTOG Plot Evaluated for Coverage of Additional Targets

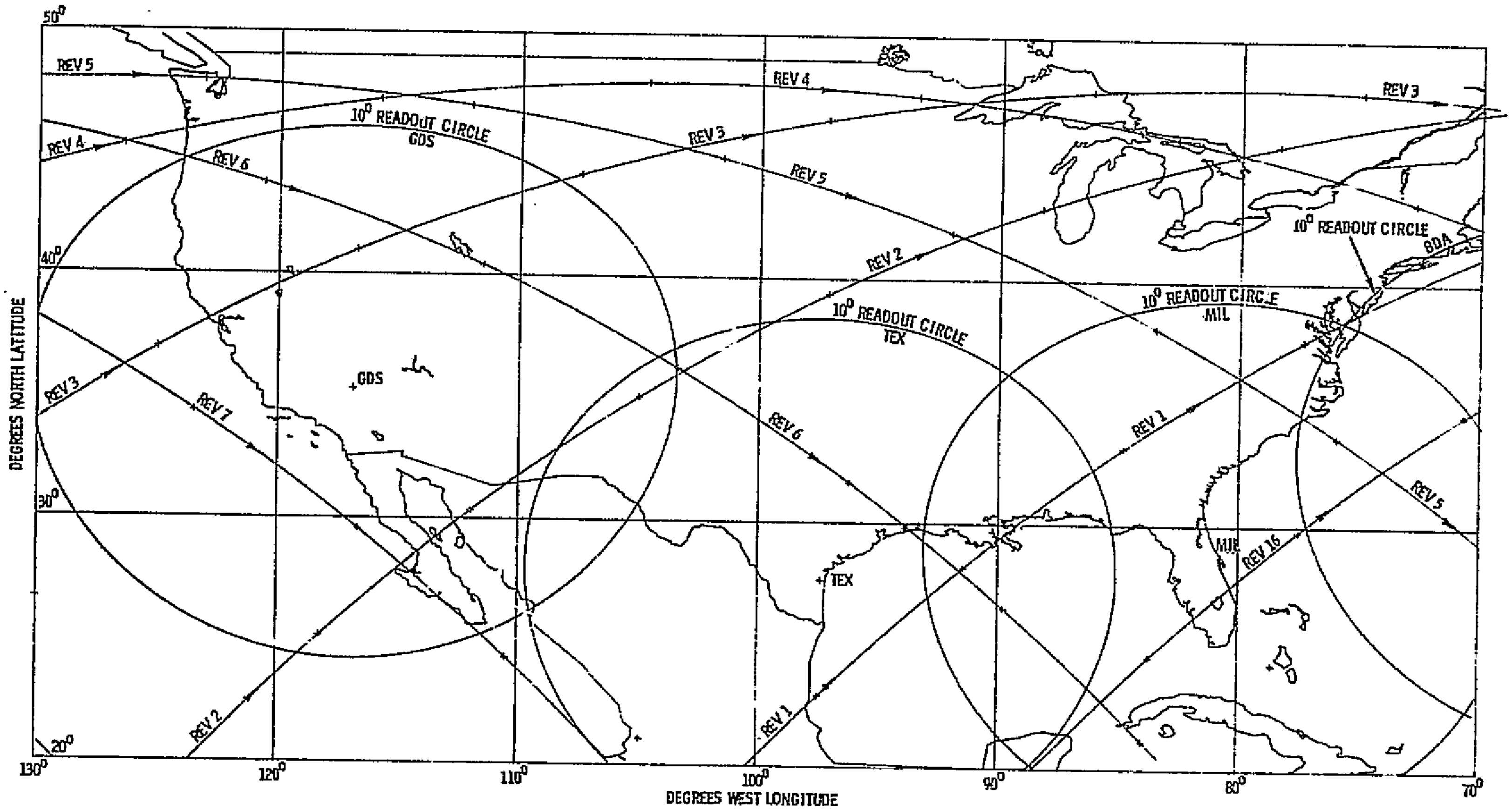


Figure 3-19. Readout for Typical Day in the Pollution Reference Mission

for each data station to indicate trajectory rise and set times. The result of these runs are discussed in detail in Section 4.

3.2.3.3 Experiment Scheduling (AESOP)

The inputs needed to run AESOP are shown in Figure 3-20. The sensor data bank consists of a resource requirements/sensor events matrix, a sequencing matrix and a list of operational priorities. The requirements matrix shows the distribution of resource requirements over the event of each mission sensor. The resource requirements of the high resolution visible imaging spectrometer (sensor number 15) are shown in Figure 3-21. The remaining resource requirements matrices may be found in Appendix C. The sequencing matrix shows all the possible event sequences for an instrument. This can also be expressed in a flow diagram as shown in Figure 3-22 for Sensor 15. The remaining sequencing matrices may also be found in Appendix C. For example, set up can only be followed by calibrate, whereas calibrate can be followed by standby or operate depending on whether or not the sensor can acquire an experiment target. The operation priorities are used as decision logic when more than one alternative exists in terms of event sequencing and when an event must be instituted periodically (time interval-dependent, not sequencing-dependent).

The mission experiment priorities were based upon a three level evaluation:

- Priority 1
  - Experiment closely relates to the central theme of the mission (phenomena, time of year, location).
  - Singular hemispheric time of year required.
  - Combination of experiments (complementary data and time-sharing of sensors).
- Priority 2
  - Less crucial to central theme of mission.
  - Not restricted to specific time of year.
- Priority 3
  - Add on/filler with respect to sensor use, target locations, weight/power, etc.

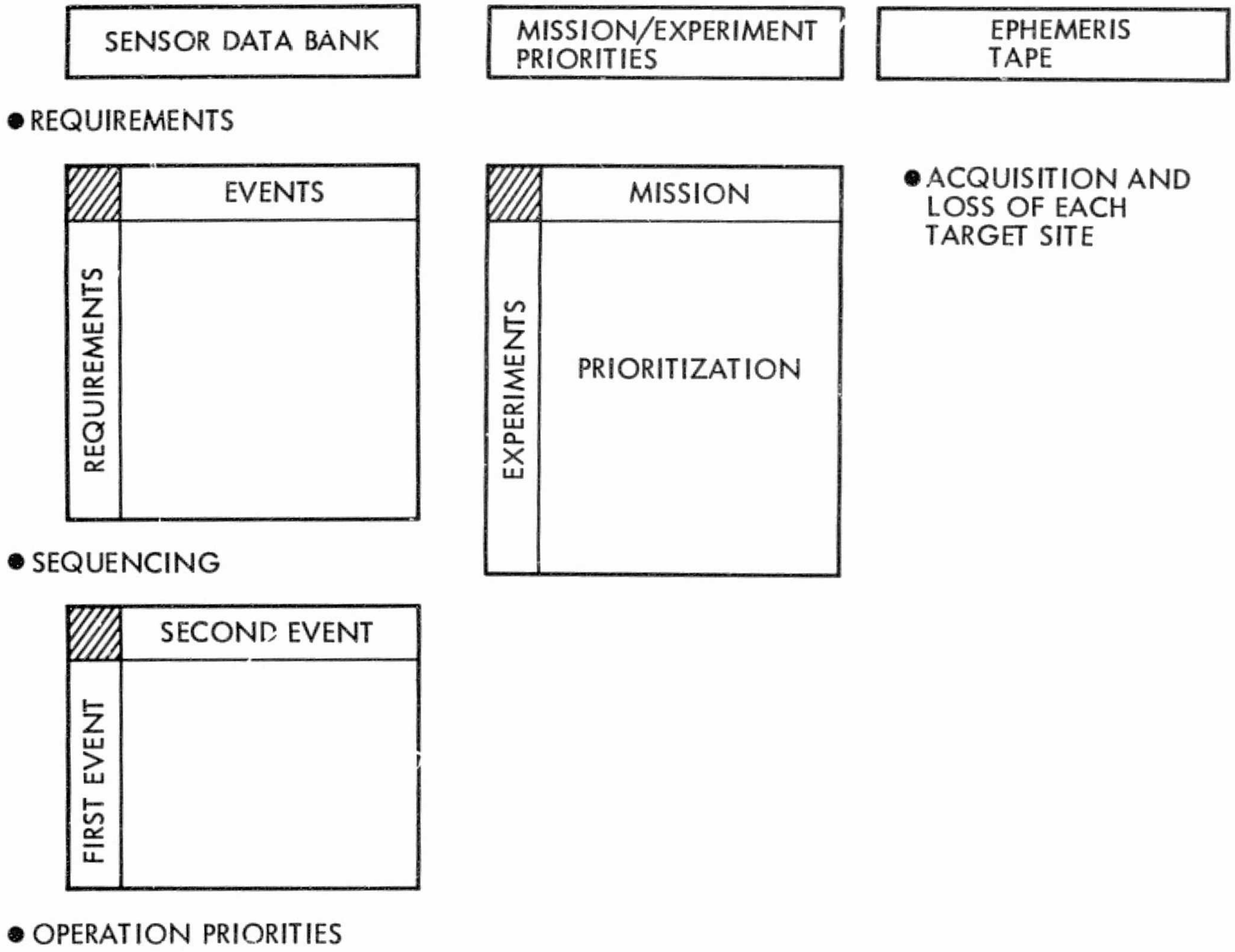


Figure 3-20. A Variety of Inputs are Required to Run AESOP

1) PHYSICAL REQUIREMENTS

- SIZE: $0.012\ M^3$ ($0.43\ FT^3$) SENSOR; $0.006\ M^3$ ($0.23\ FT^3$) GIMBALS
- WEIGHT: 13.6 KG (30 LB) SENSOR; 11.4 KG (25 LB) GIMBALS
- POWER: 25 W SENSOR; 25 W (AV), 100 W (PK) GIMBAL

2) REQUIREMENTS

REQUIREMENT	EVENTS				
	SET UP/ MODIFICATION	CHECKOUT CALIBRATION	OPERATE	STANDBY	SHUT DOWN
DURATION (STANDARD, OR MIN/MAX)	10 MIN (WARM-UP)	5 MIN	18 SEC (3 FRAMES) PER TARGET	TIME BETWEEN TARGETS	OVER LAND MASSES AND DURING ECLIPSE
POWER	50 W	125 W (2-AXIS POINTING)	125 W (2-AXIS POINTING)	50 W	0 W
DATA	-	6 KB/S	6 KB/S	-	-
FILM	-	-	-	-	-
MANPOWER	1/2	1	1	0	0
SPECIAL					

3) CONFLICTS WITH OTHER SENSORS : NONE

Figure 3-21. The Resource Requirements for Sensor 15, High Resolution Visible Imaging Spectrometer

FIRST EVENT \ SECOND EVENT	1	2	3	4	5
1		X			
2			X	X	
3				X	X
4			X		
5	X				

OPERATION PRIORITIES

- CALIBRATE OCCURS ONCE/2 DAYS
- SHUTDOWN OCCURS AT THE END OF THE LAST OPERATE

EVENTS

1. SET UP
2. CALIBRATE
3. OPERATE
4. STANDBY
5. SHUTDOWN

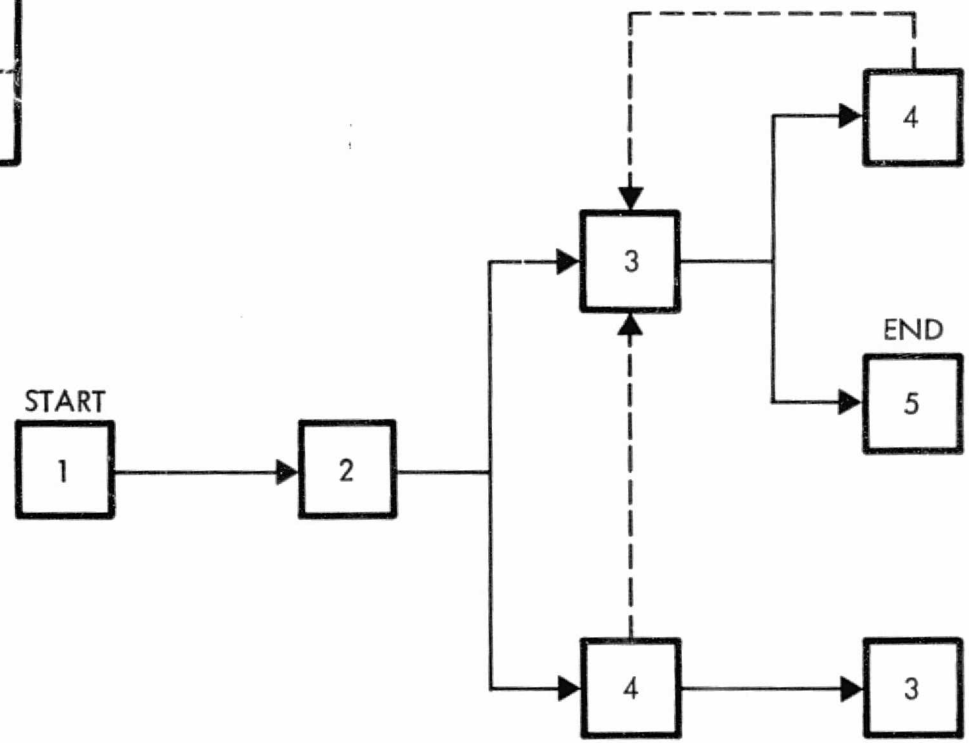


Figure 3-22. Event Sequencing for Sensor 15, High Resolution Visible Imaging Spectrometer

– Absolutely neutral with respect to time of year and/or geographic location of targets.

The experiment priorities for the pollution reference mission are:

Experiment	Priority
Regional water pollution monitoring	1
Air pollution monitoring	1
Lake Eutrophication studies	1
Coastal geology and geomorphic processes	2
Urban survey	2
Geologic and topographic mapping	2
International development project	2
Stellar occultation	3
Wildlife-ecosystem studies	3

The final input required to run AESOP is an ephemeris tape. This tape is supplied by the OTO program. An example of the tape is shown in Table 3-4. The targets are consecutively numbered for all the experiments.

The output of AESOP consists of experiment schedules and resource summaries as shown in Figure 3-23. The pollution mission experiment and sensor timelines for a two day coverage cycle are displayed in Appendix D. A detailed power timeline is also shown in Appendix D. A summary of the power requirements is shown in Figure 3-24, as well as an example of an operating period. The electrical power presently baselined to be available in the Sortie Lab for payload usage (exclusive of that available to the payload from the orbiter) is:

- Average 7 kW
- Peak 10 kW for 6 minutes
- Peaking power kit(s) (tentative).

As shown in Figure 3-24, during operating periods the sensors require almost all the power available. This difficulty will be discussed in Section 5 and in Volume III - Section 7.0.

The data requirements, both digital and film, are tabulated in Tables 3-5 and 3-6, respectively. These data requirements are for a

Table 3-4. Ephemeris Tape for Pollution Reference Mission

TIME FROM LAUNCH	ENTER/EXIT	EXPERIMENT	TARGET
24.205	ENTER	OT3	80
24.218	EXIT	OT3	80
24.261	ENTER	O1	80
24.282	EXIT	O1	80
24.283	ENTER	M4	28
24.290	ENTER	M4	27
24.295	EXIT	M4	28
24.297	ENTER	G2	121
24.303	EXIT	M4	27
24.308	EXIT	G2	121
24.311	ENTER	G2	122
24.320	ENTER	O1	15
24.324	ENTER	OT3	62
24.325	ENTER	M4	34

Table 3-5. Pollution Mission Digital Data Requirements for Each Coverage Cycle

SENSOR	RATE	ACTUAL TIME	DATA TAKEN
8	200 MB/S	1.748 HR	1.26×10^6 MB
9	6.94 KB/S	860 SEC	5.97 MB
12	150 B/S	1.353 HR	0.73 MB
13	378 KB/S	0.981 HR	1.33×10^3 MB
14	7.45 MB/S	0.701 HR	1.88×10^4 MB
15	6 KB/S	0.096 HR	2.07 MB
16	240 KB/S	0.064 HR	5.53×10^1 MB
19	1.6 KB/S	0.327 HR	1.88 MB
20	500 B/S	0.327 HR	0.589 MB
21	7 B/S	0.327 HR	0.008 MB
22	20 KB/S	0.064 HR	4.61 MB
23	1.2 KB/S	0.327 HR	1.41 MB
25	3.6 KB/S	0.327 HR	4.24 MB
26	3.6 KB/S	0.327 HR	4.24 MB
27	1.12 KB/S	0.327 HR	1.32 MB
28	3 KB/S	0.327 HR	3.53 MB
29	200 B/S	1.135 HR	0.812 MB

TOTAL DATA TAKE: 1.280214×10^6 MB

Table 3-6. Pollution Mission Film Requirements for Each Coverage Cycle

SENSOR	FILM	OPERATION RATE	FRAMES TAKEN
1	35MM	1 FRAME/MINUTE	179
2	70MM	1 FRAME/10 SEC	107
3	11.5 x 128 CM	1 FRAME/10 SEC	419
4	24 x 48 CM	1 FRAME/TARGET	60
5	24 x 24 CM	2 FRAMES/TARGET	146
6	70MM	6 FRAMES/TARGET	240
7	24 x 24 CM	3 FRAMES/TARGET	24
9	16MM	2 FRAMES/TARGET	86
10B	70MM	CONTINUOUSLY OVER SELECTED TARGETS	TBD
11A	70MM		TBD

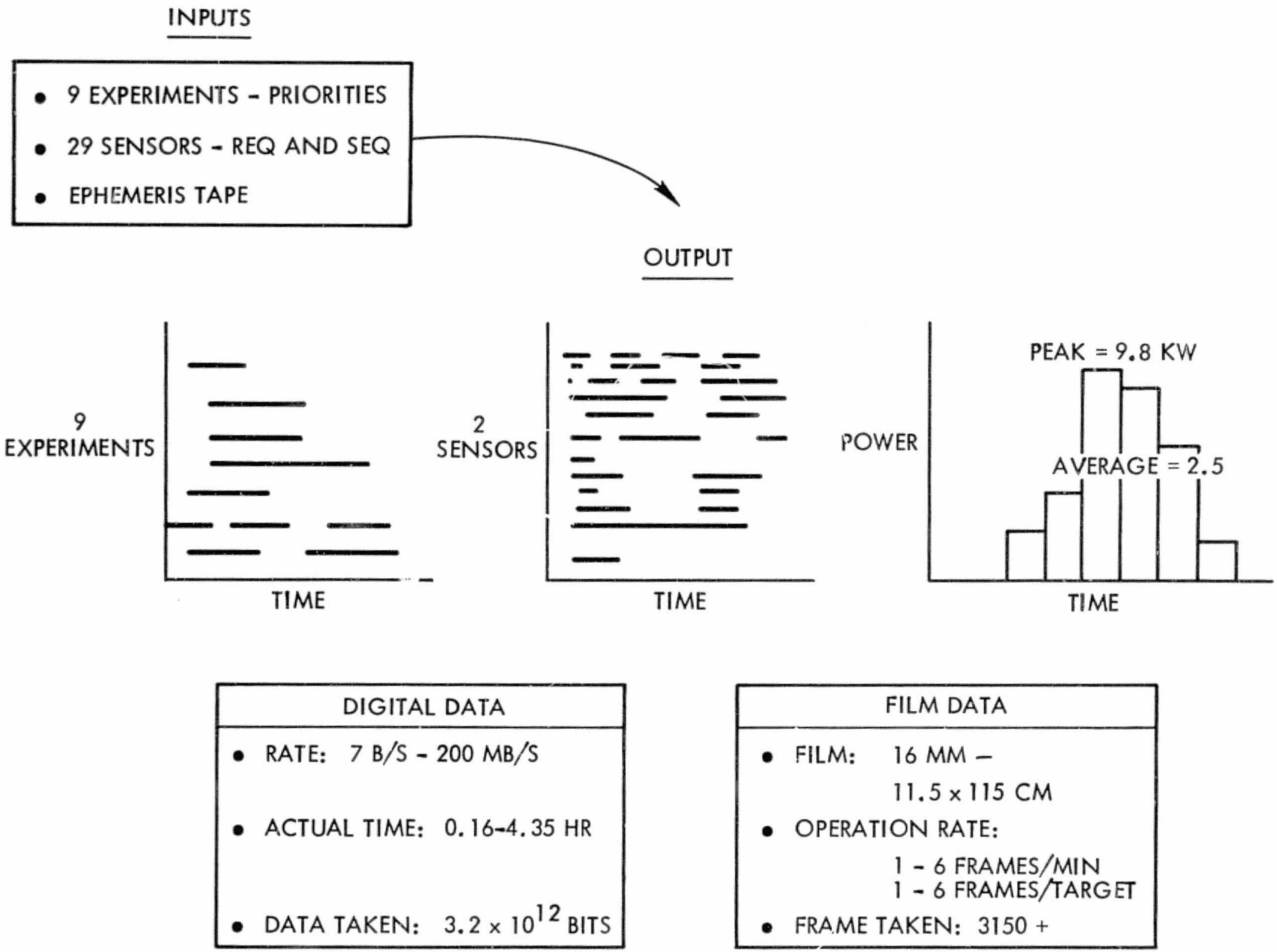
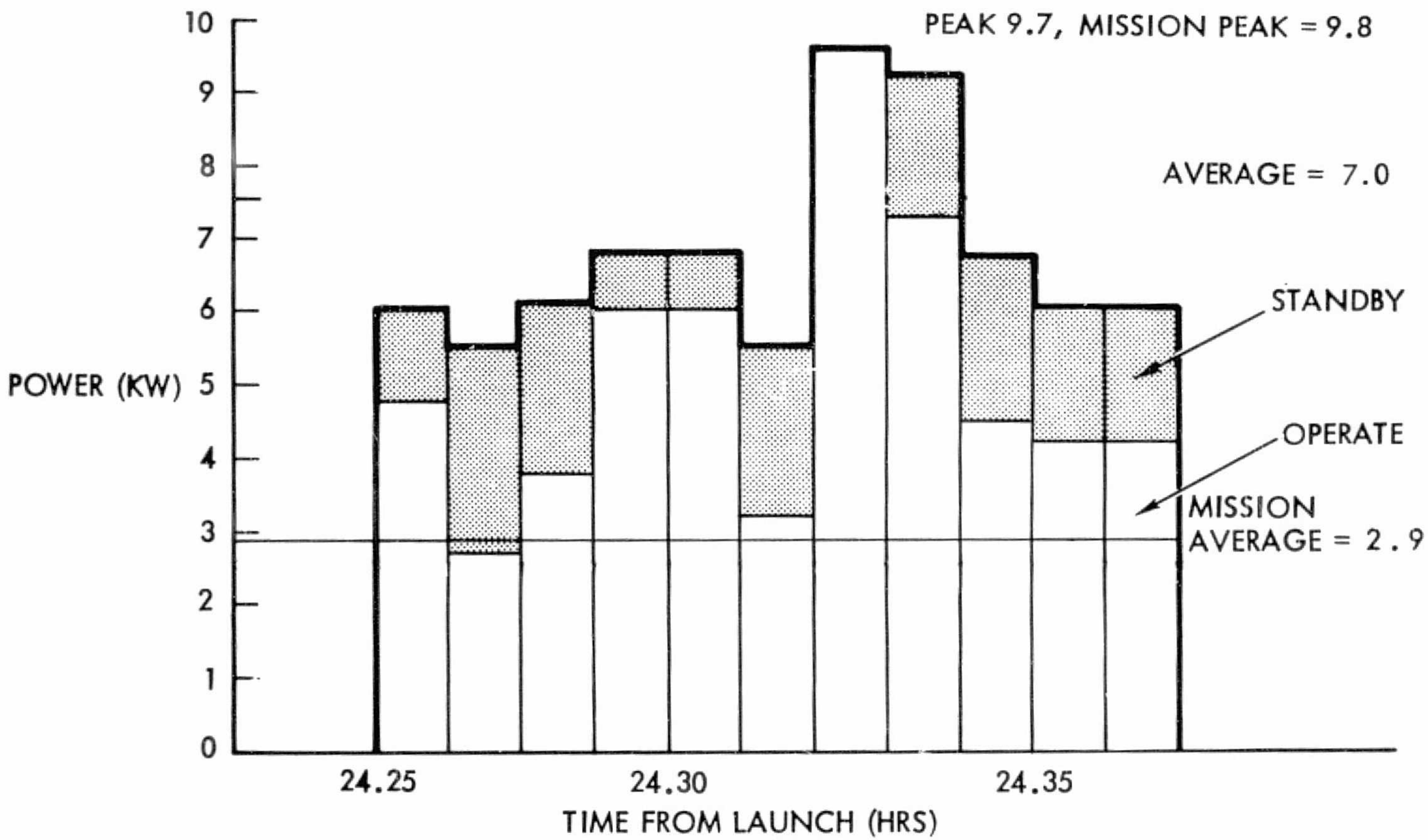


Figure 3-23. AESOP Is Used to Generate Experiment Scheduling and Requirement Summaries



AVERAGE FOR ALL OPERATING PERIODS = 5.4 KW
PEAK IN NONOPERATING PERIODS = 5 KW

Figure 3-24. Pollution Reference Mission Power Timeline for an Operational Period

two day coverage cycle. Since the mission is five days in length, the total data requirements may be obtained by multiplying the coverage cycle requirements by 2.5. The primary contributor to the 3.2×10^{12} bit mission requirement is sensor 8, a 20-band multispectral scanner which has a data rate of 200 Mb/sec and is used 4.37 hours. The film requirements for the camera systems can easily be accommodated by state-of-the art film magazines (i.e., the magazines will not have to be replaced). The two radars, sensors 10B and 11A might be a problem in terms of data storage on film, but because of later mission considerations (Section 5) this problem was not investigated.

4.0 BASELINE MISSION ANALYSIS

4.1 SENSOR/EXPERIMENT COMMONALITY

Figure 4-1 shows how 29 of the 33 MEO sensors are allocated to the nine experiments making up the Pollution Mission. The sensor package for each experiment (with the exception of M2, Stellar Occultation), consists of a varied grouping of sensors which are intended to satisfy the documented Level I experiment requirements. Three sensors (1, 2, and 32) find essentially universal use by the experiments, while 11 (38 percent) of the sensors are experiment-unique. Among the latter are nine that are unique to the Air Pollution experiment, one (the Synthetic Aperture Radar, 10) that is unique to the Water Pollution experiment, and one (the Star-Tracking Telescope, 18) that is both unique to, and the only sensor required for, the Stellar Occultation experiment.

Only the Stellar Occultation experiment requires a single sensor (the Star-Tracking Telescope) ; each of the other eight experiments require from seven to fourteen sensors, with the Air Pollution experiment having the largest complement of (as well as most of the experiment-unique) sensors.

As a class, the six camera systems find the widest use, with one-half or more (of the class) being used in all but the Meteorology experiments. In the multisensor Air Pollution experiment, the emphasis is on radiometers, interferometers, spectrometers, a polarimeter and a gas filter optical correlation sensor, with a pointable identification camera used to record the scene during data-gathering periods.

NO.	SENSOR \ EXPERIMENT	WATER POLLUTION (O1)	STELLAR OCCULTATION (M2)	AIR POLLUTION (M4)	WILDLIFE-ECOSYSTEMS (AFR3)	COASTAL GEOLOGY & GEOMORPHIC PROCESSES (G2)	MOUNTAIN AREA MAPPING (G4)	LARGE EUTROPHICATION (E2)	INT'L DEVELOP. PROJECT (OT2)	INT'L METRO AREA BIENNIAL UPDATE (OT3)	NO. OF EXPERIMENTS USING SENSOR	
1	TRACKING TELESCOPE	X		X	X	X	X	X	X	X	8	
2	POINTABLE IDENT CAMERA	X		X	X	X	X	X	X	X	8	
3	PAN CAMERA					X	X		X	X	4	
4	WIDE-ANGLE CAMERA					X	X		X	X	4	
5	MS CAMERA	X			X	X	X	X	X		6	
6	HIGH RES MS CAMERA	X						X			2	
7	MULTIRES CAMERA				X	X	X	X	X	X	6	
8	HIGH RES MS SCANNER				X	X	X	X		X	5	
9	LWIR SPECT					X	X				2	
10	WIDEBAND SAR	X									1	
11	MULTIFREQ WIDEBAND SAR					X	X		X		3	
12	LASER ALT/SCAT	X					X				2	
13	VIS IMAG SPECT	X						X			2	
14	IR MS MECH SCANNER	X						X			2	
15	HIGH RES VIS IMAG SPECT	X						X			2	
16	HIGH RES IR MS SCANNER	X						X			2	
18	STAR TRACK TELESCOPE		X								1	
19	UV UPPER ATMOS SOUNDER			X							1	
20	VIS RAD POLARIMETER			X							1	
21	AIR POLL CORREL SPECT			X							1	
22	HIGH SPEED INTERFER			X							1	
23	CO POLL EXPT			X							1	
25	GAS FILTER CORREL			X							1	
26	ADV LIMB RAD INVERS RAD			X							1	
27	TIROS-N ADV VERY HI RES RAD			X							1	
28	TIROS-N OPER VERT SOUNDER			X							1	
29	PASSIVE MICROWAVE RAD			X		X	X				3	
32	WIDE ANGLE VIEWER	X		X	X	X	X	X	X	X	8	
33	DATA COLLECT SYSTEM	X		X	X	X		X			5	
	NO. OF SENSORS PER EXPERIMENT	12	1	14	7	12	12	12	8	7	29	← MISSION TOTAL
	NO. OF EXPERIMENT-UNIQUE SENSORS/EXPERIMENT	1	1	9	0	0	0	0	0	0	11	← MISSION TOTAL

Figure 4-1. MEO Sensor Usage in Pollution Mission

4.2 DATA HANDLING AND MANAGEMENT

4.2.1 Digital Data

Most of the instruments on the pollution reference mission obtain digital data. The primary data contributor is sensor number 8, a 20-band multispectral scanner. This data can be handled by on-board storage in tape recorders with capacities up to 10^{11} bits at rates as high as 200 Mb/s.

4.2.2 Film Data

The camera systems and radars store data on film. Conventional film magazines can accommodate the number of frames taken by the camera systems on the pollution reference mission.

The volume of film required for recording SAR data can be obtained by considering a state-of-the-art cathode ray tube (CRT) with a spot size of 25μ and sensor 11A, a dual polarized, three frequency radar with a ground resolution of 30 m. It is assumed that the film is coupled to the CRT by fiber optics. Six CRT's will be required. With a ground resolution of 30 m, one "A" scan will have to be generated for every 30 m of motion of the spacecraft. With a subsatellite velocity of 7 km/sec, 233 "A" scans will have to be produced every second. With a film packing density of 24 "A" scans/mm the film velocity will be 9.7 mm/sec. Assuming continuous coverage is desired over the Continental United States, ~ 300 minutes of data will be obtained in a five day mission. By multiplying this value by the film velocity, a film requirement of 174 m for each polarization and frequency combination is obtained. The remaining radar, sensor 10B is a single polarization, single frequency sensor with a spatial resolution of 30 m so it would require only one CRT and 174 m of film. Therefore, the film requirements appear to be easily met. The requirement for 7 CRTs may create a volume problem in the Sortie Lab.

4.2.3 Ground Station Visibility Times

On any given Shuttle Sortie earth observation mission there may be a requirement to transmit data to the ground. For example, if a tropical storm has developed into a hurricane off the coast of the United States there may be a requirement for observations (more detailed or sophisticated than would be normally available) using several of the Shuttle sensors.

These data would be used to enhance the storm warning and damage assessment capabilities of those agencies responsible for such activity. This information would be needed as soon as possible. Using the S-band ground link on the Orbiter, information could be relayed to the ground whenever the Orbiter was within the readout circle of a given data station.

To assess the potential data dump capability of the Manned Earth Observatory on a pollution mission, the Manned Space Flight Network (MSFN) was used in a computer simulation to determine the range of ground station visibility times that would occur. This was accomplished by using the RISET and CARTOG computer programs described in Section 3.2. The data handling capability of the Manned Earth Observatory during an on-call, potential disaster situation is discussed in Section 4.4.

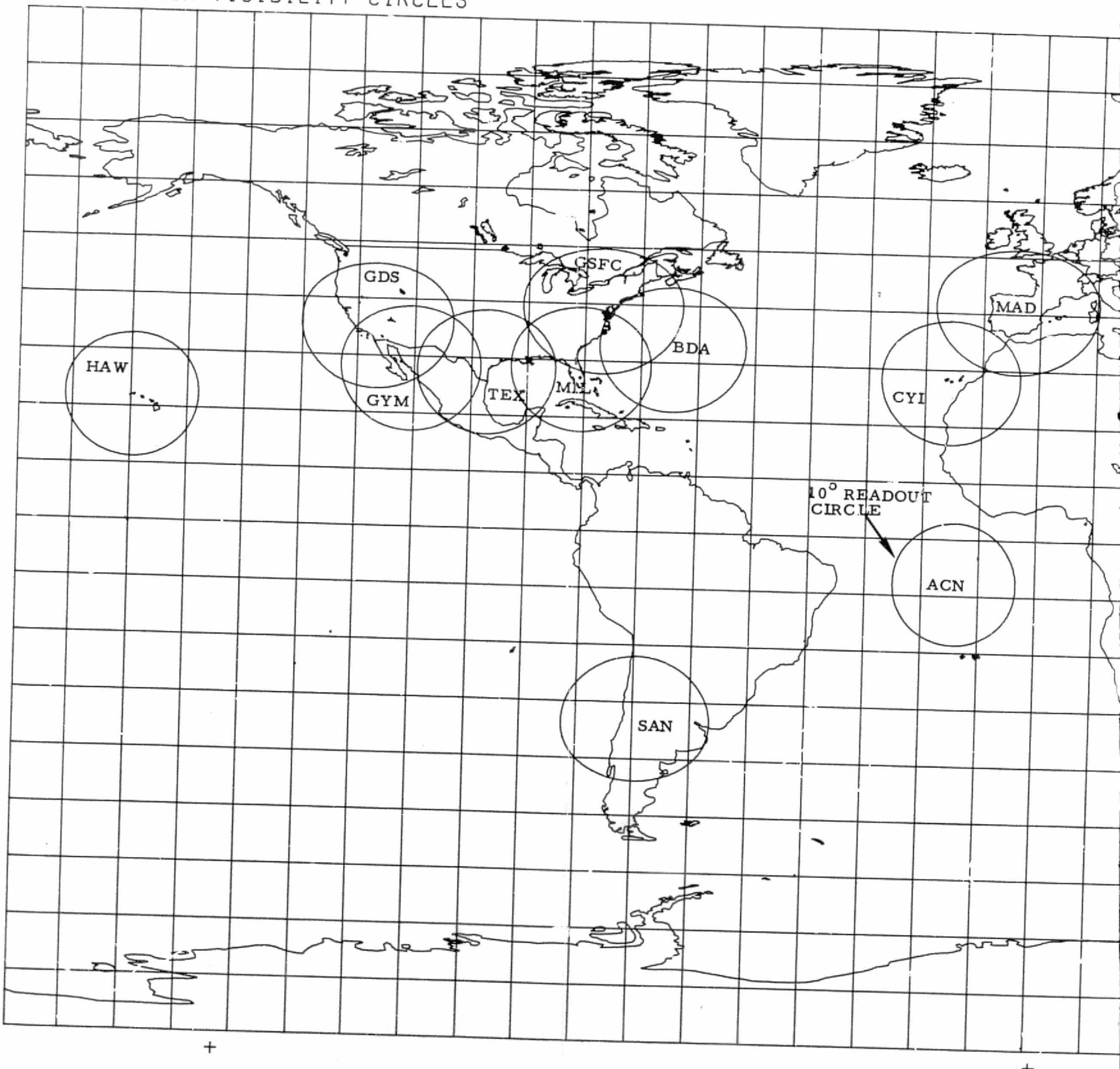
The MSFN is a world-wide tracking and data acquisition system that was established by NASA to support manned spaceflight programs. It consists of land based stations, located around the world between the latitudes of approximately 40 degrees North and 40 degrees South, supplemented by one instrumentation ship. Table 4-1 lists the network stations and their geodetic coordinates. Figure 4-2 illustrates the geographic location and distribution of the stations. The Goddard Space Flight Center (GSFC) is included on the map because it is the MSFN Operations Center.

RISET was used to determine the ground station visibility time history for a two day coverage cycle of the 183 nautical miles, 48 degree pollution reference mission orbit. A CALCOMP plot of the visibility time history is shown in Figures 4-3 and 4-4. A summary of the results is displayed in Figure 4-5. The amount of time available for dumping data at any one station in one orbital revolution varies from one minute to six minutes (see Figure 4-5). Assuming an S-band transmission rate of 1 Mbps, 360 Mb can be dumped in six minutes to a ground station per revolution. If data obtained by sensor number 8 is to be dumped, there may be problems because of its exceptionally high data rate (in six minutes only 1.8 seconds worth of sensor 8 data could be dumped). Figure 4-5 shows that at least 20 minutes of ground link transmission time are available with the stations in the five day mission time period.
in the five day mission time period.

Table 4-1. MSFN Station Designators and Geodetic Coordinates

Station	Station Designator	Latitude	Longitude
Ascension Island, U.K.	ACN	$-07^{\circ}57$	$345^{\circ}40$
Bermuda, U.K.	BDA	$32^{\circ}20$	$295^{\circ}20$
Carnarvon, Australia	CRO	$-24^{\circ}53$	$113^{\circ}43$
Grand Canary Island, Spain	CYI	$27^{\circ}45$	$344^{\circ}21$
Goldstone, California	GDS	$35^{\circ}20$	$243^{\circ}7$
Guam	GWM	$13^{\circ}18$	$144^{\circ}44$
Guaymas, Mexico	GYM	$27^{\circ}57$	$249^{\circ}16$
Kokee Park, Kauai, Hawaii	HAW	$22^{\circ}07$	$200^{\circ}20$
Honeysuckle Creek, Australia	HSK	$-35^{\circ}35$	$148^{\circ}58$
Madrid, Spain	MAD	$40^{\circ}27$	$355^{\circ}49$
Merritt Island, Florida	MIL	$28^{\circ}30$	$279^{\circ}18$
Santiago, Chile	SAN	$-33^{\circ}09$	$-69^{\circ}40$
Corpus Christi, Texas	TEX	$27^{\circ}39$	$262^{\circ}37$
Tananarive, Malagasy Republic	TAN	$-19^{\circ}00$	$47^{\circ}18$

MSFN STATION VISIBILITY CIRCLES



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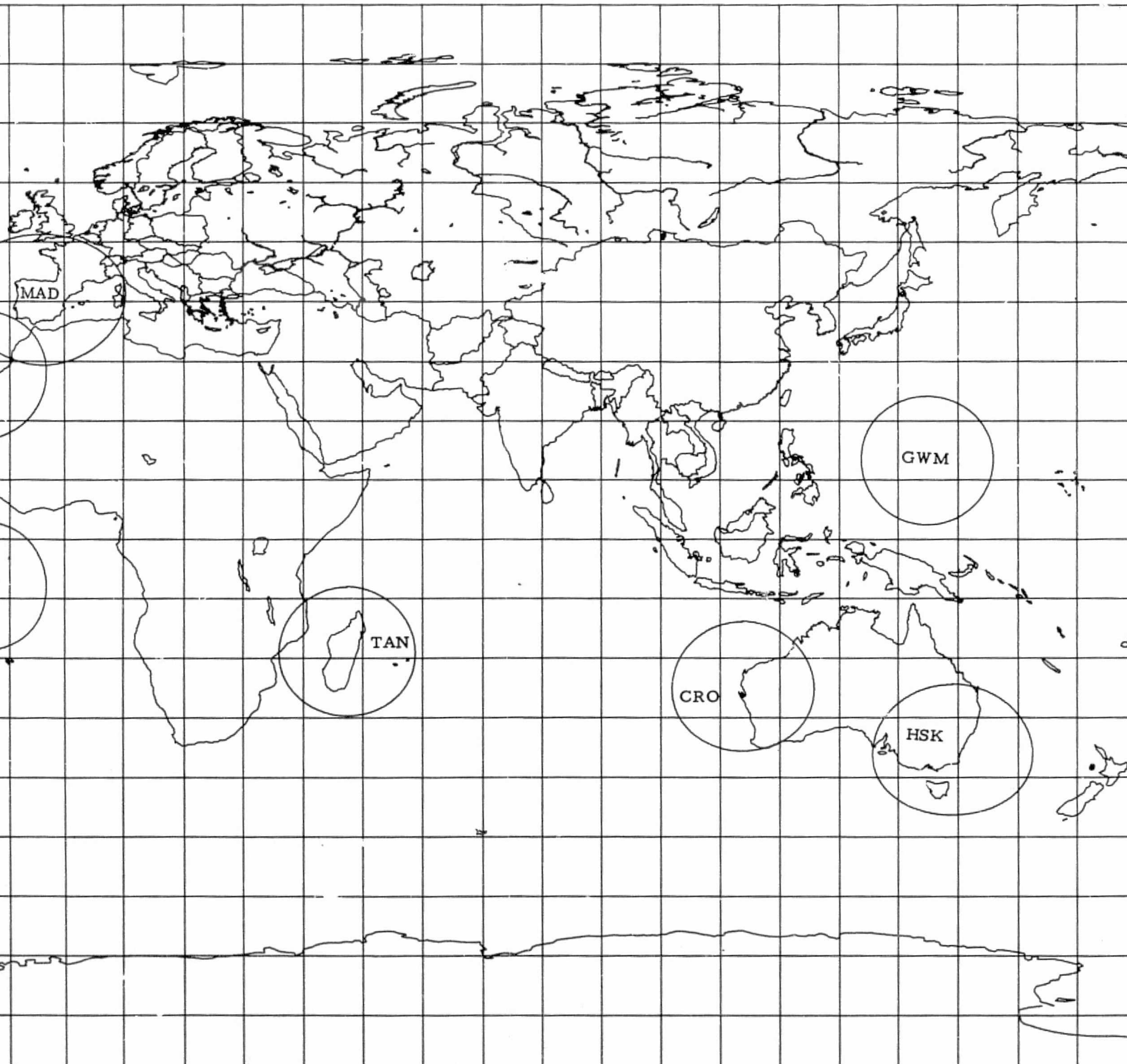

Figure 4-2. Geographic Location of the MSFN Stations

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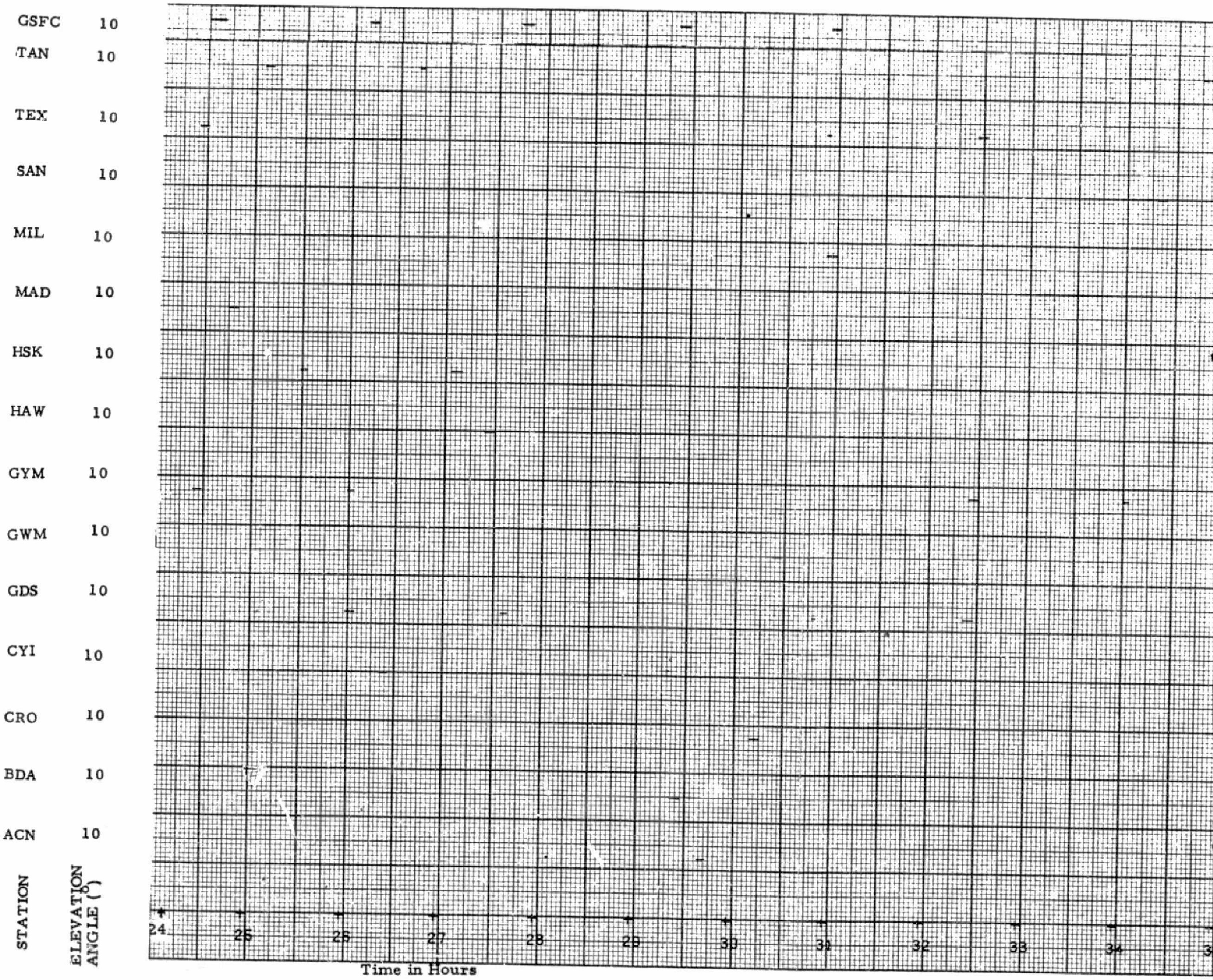

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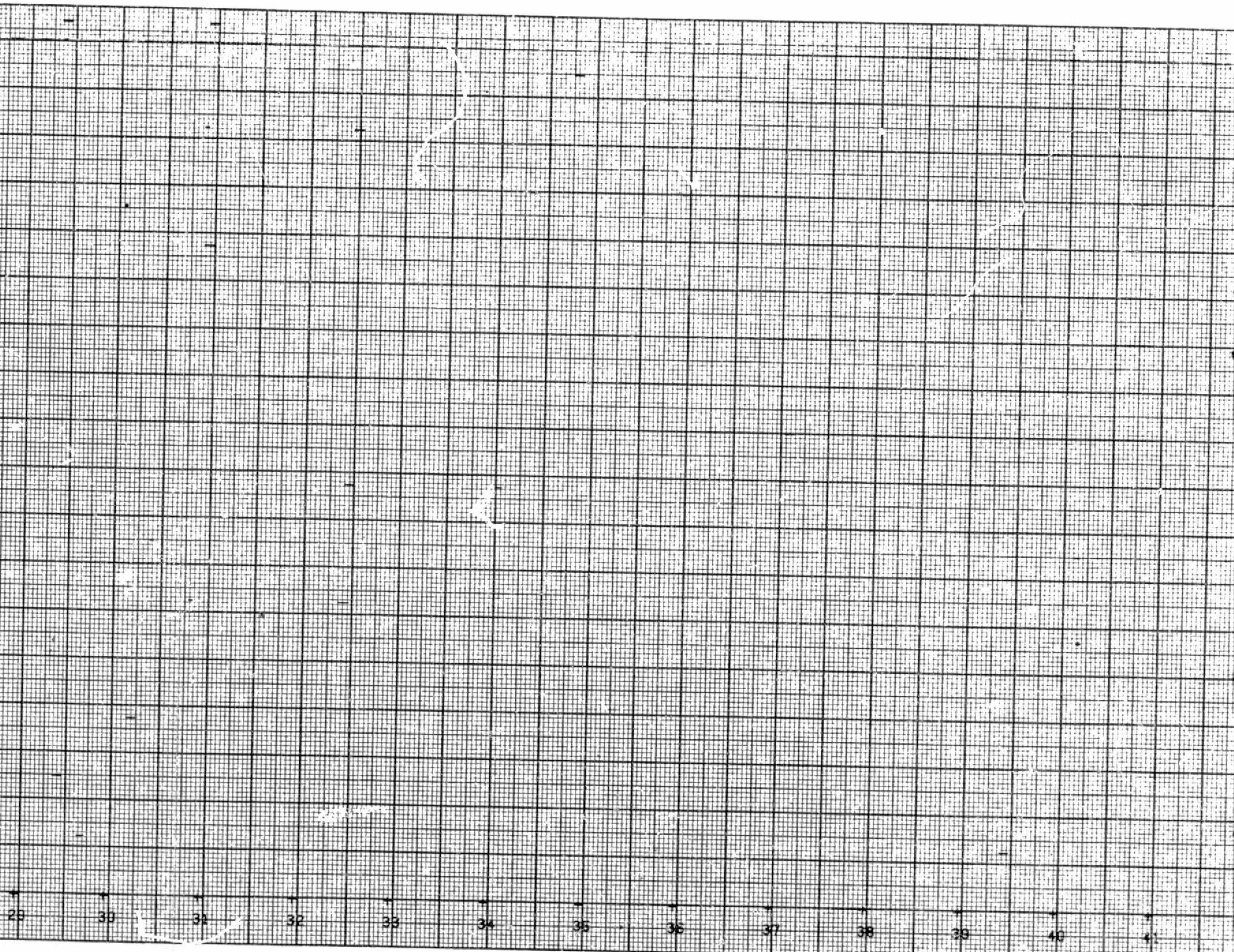


FOLDOUT FRAME 2

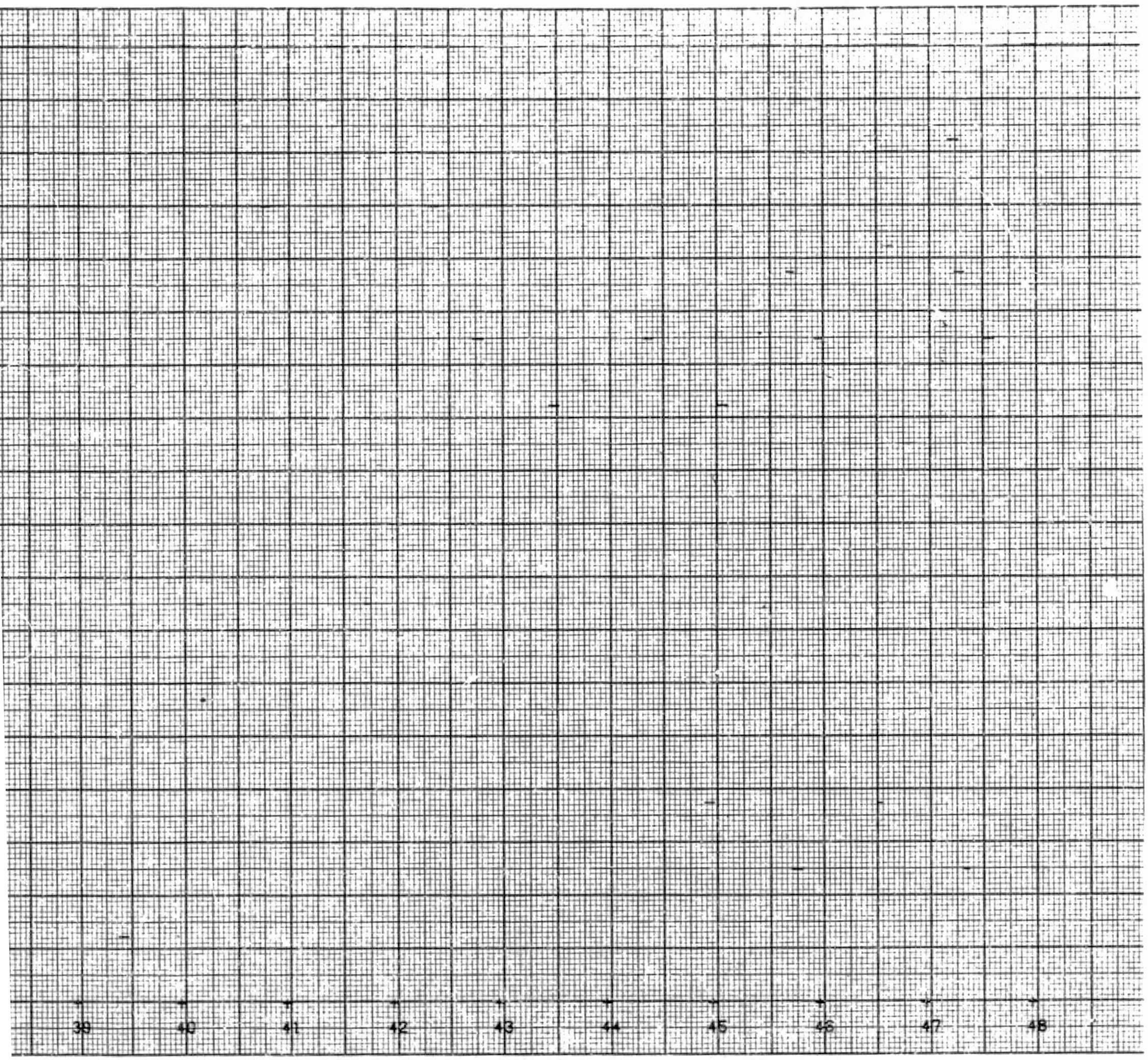
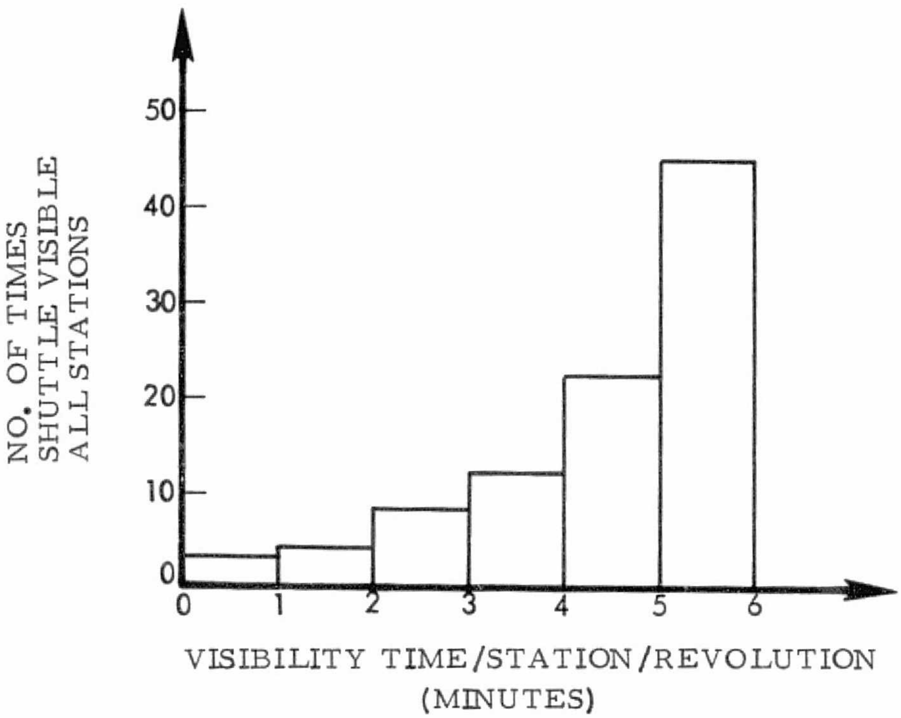


Figure 4-4. Pollution Reference Mission
Ground Station Visibility Times
(Second Day of Two-Day Coverage Cycle)

A. ALL STATIONS (TOTAL MISSION)



B. PER STATION (TOTAL MISSION)

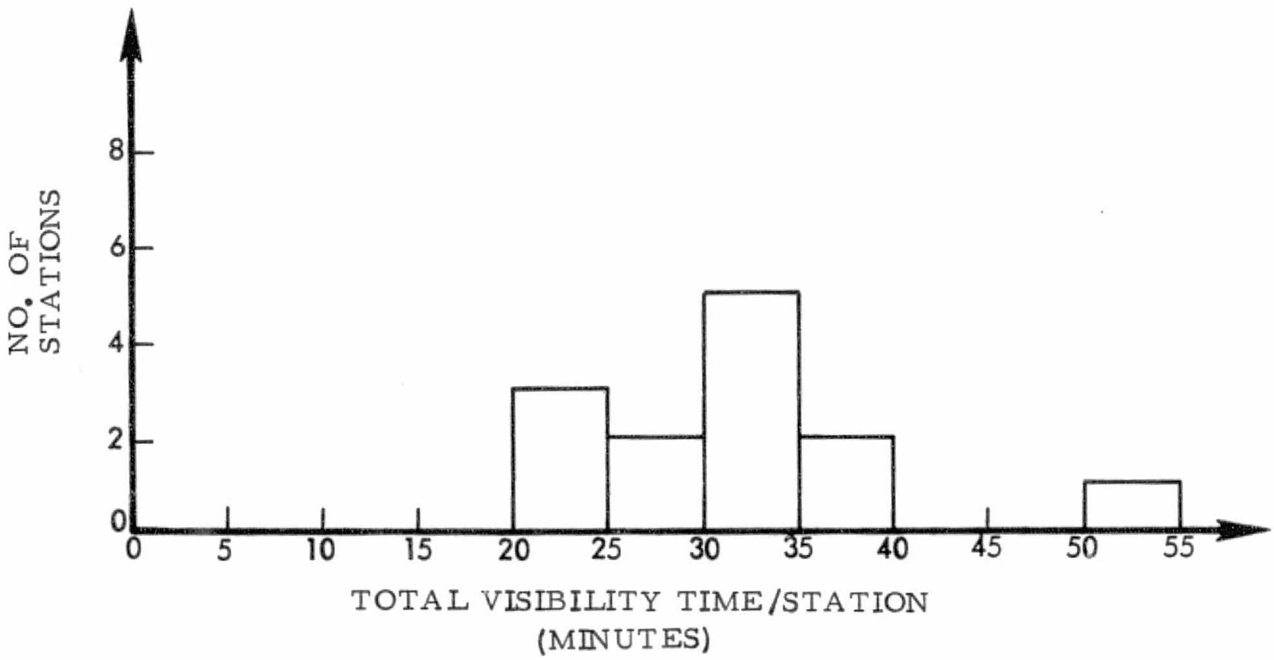


Figure 4-5. Ground Station Coverage Histograms

4.3 ROLE OF MAN

4.3.1 Introduction

Design studies of candidate earth observation experiments for the Shuttle Manned Earth Observatory have suggested an important role for man. The multi-sensor, multi-objective character of the candidate Shuttle-MEO missions, together with the special calibration and other requirements of particular experiments may, in fact, make man absolutely necessary. Optimum utilization of the many capacities of man will, however, require comprehensive consideration of the man/sensor interface system and a rigorous training program.

The functions to be performed by man have been examined in the somewhat constraining framework of the candidate Priority I Mission directed at pollution problems. The sensor complements are generally off-the-shelf and are therefore not specially designed to permit man to change instrument performance characteristics or to require special attention as other instruments may necessitate. Similarly, the Sortie Lab with pallet configuration is not designed for maximum access to the sensor packages and man's role may be limited in the area of sensor deployment.

Some commentators on the role of man for space earth observation programs have implied that man has exceptionally wideband data processing and control capabilities. We know of no evidence that man's input bandwidth is even comparable to current sensor standards and his communicative output capabilities which, when complemented by equipment to extend his visual characteristics and when interfaced with machine sensor controls, extend these capacities far beyond those of a machine data processing system.

In considering the role of man in these several modes we have drawn upon a body of literature generated over the past decade on the subject and have examined the described functions in the context of the individual candidate experiments and mission through use of scenarios, reference to similar manned space missions, and review of aircraft scientific experimentation. The following sections will seek to identify and weigh man's contribution to the candidate Shuttle - MEO Pollution

Mission and recommend the types of instruments and control interfaces to optimize that contribution.

4.3.2 The Roles of Man in a Manned Earth Observatory

(See Figure 4-6)

4.3.2.1 Pollution Mission – Role of Man's Evaluation

The candidate experiments comprising the Priority I Pollution Mission have been discussed in detail in Volume I of this study. The sensor systems and observational requirements of this mission are about as complex as are likely to be experienced in MEO missions. Manned interaction may be required simply to operate and select appropriate targets (predictable but not easily programmed for very high-resolution sensors). The specific functions for man discussed below represent a compilation based on our experiments and literature review.

4.3.2.2 High-Resolution Target Selection

Experience with the Apollo G/N tracking telescope has defined a need for an interface between the viewing telescope and the G/N computer of the spacecraft. Coarse pointing can then be accomplished in an automated mode with the scientific director providing the final target selection and image centering. A programmed instruction set with manual override could be used as the basis of the planned orbital parameters and target locations.

4.3.2.3 Documentation and Annotation

A characteristic problem with some of the early manned earth observation efforts was a lack of documentation of the photographs. Man as a scientific observer/experimenter should be charged with the task of assuring that the observations are appropriately documented. Man's primary role in this task will be to verbally note features that cannot be electronically or mechanically documented. Appropriate interfaces should be provided to permit accurate time (after day of launch and absolute) correlation with the sensor records.

FUNCTIONS	AIR POLLUTION MONITORING	REGIONAL WATER POLLUTION	LAKE EUTROPHICATION	COASTAL GEOL COASTAL PROC	URBAN SURVEY	GEOL/TOPO MAPPING IN MTS	INT'L DEV	STELLAR OCCULTATION	WILDLIFE ECOSYSTEM
	EXPERIMENTS								
HIGH RESOLUTION TARGET SELECTION	1	1	1	1	1	2	1	1	1
DOCUMENT/ANNOTATE	1	1	1	1	1	1	1	1	1
PRIORITY/COORDINATE	1	1	1	1	1	1	1	1	1
TARGETS OF OPPORTUNITY	1	1	1	1	1	1	1	1	1
INTERPRET/GENERALIZE	1	1	1	1	2	2	3	1	2
IMAGE SIGNATURE ANALYSIS	1	1	1	2	3	2	2	-	1
IMPROVISION	1	1	2	1	2	1	1	1	1
INSTRUMENT EXP AND REPAIR	2	2	2	1	2	2	3	1	3
CALIBRATION AND EVALUATION	1	1	1	1	3	1	1	1	1
PROCESSOR AND DISPLAY, REST AND EVAL	1	1	1	1	2	1	2	3	2
SENSOR AND ANTENNA DEPLOYMENT	2	2	2	1	2	1	2	1	2
DATA PACKAGING	1	1	1	1	1	1	1	1	1
REPORT PREPARATION	1	1	1	1	1	1	1	1	1
COMMUNICATION	1	1	1	1	1	1	1	1	1

CODE: 1 MAN ESSENTIAL
2 MAN USEFUL
3 NO ROLE FOR MAN

Figure 4-6. Pollution Reference Mission Role of Man

4.3.2.4 Priority Establishment and Coordination

Multiple experiments and sensors in association with many diverse targets will require a significant amount of emphasis on priority and coordination. Man can play a highly significant role in choosing among various targets to pick the most important. Man can play a major role in coordinating the ground teams and in coordinating the onboard experimental program.

4.3.2.5 Targets of Opportunity

Man plays a highly significant role as a part of his scientific observational tasks in taking advantage of targets of opportunity. It is important to note that "targets of opportunity" includes two classes of targets; those that generally can be predicted, such as a well-developed tropical storm, and those that cannot be predicted as, for excample, the birth of an undersea volcano. In the former case, a program modification plan can be developed by ground control; in the latter case, the onboard scientific observer must act to record the event in as accurate and timely a manner as possible. Once the observational routine is completed, the ground controller must assess the impact on the mission.

4.3.2.6 Interpret and Generalize

To the extent that the onboard scientist can be aware of the phenomenon that he is observing, through its visual manifestations, he is in an optimum position to interpret what he sees. Even with a well designed sensor control system, it is questionable that all associated training of the scientist/observer will be suitably recorded.

A most important element of the candidate experiments then is the interpretation of the perceptions of the scientist. These must be recorded on the spot and automatically correlated to the sensor records.

The degree of interpretation that can be accomplished is controlled by the degree to which scientist/observer awareness can be engineered into the experimental program and by the relevant knowledge and associated training of the scientist/observer. Individuals vary widely in their perceptiveness, independent of knowledge and training. Because

of this, emphasis should be given to scientist/observer selection where some method of testing individual perceptiveness can be employed.

Generalization becomes possible after a number of repetitions of the experimental procedure. It may cover evaluations of the equipment, discovery of peristent or repetitious features in the observed data, and will inevitably include a succinct evaluation of the overall performance of the experiment.

4.3.2.7 Image Signature Analysis

This activity will in one manner or another, be a continuing task for the scientist/observer. Its performance is implicit in many of the prior functions. Specifically, the task involves classification of a phenomena or event based on current data. The classification rules will be either deterministic or probabilistic, but they are generally unknown prior to analysis. This function is experiment oriented, and as stated earlier, is an implicit part of other functions. The function may be thought of as an integration of observations.

Some specific signature analysis activities will be performed by man using onboard processors and displays. The skill requirements are of a high order.

The communications system, controls and displays, must be carefully defined to permit optimum involvement of man in the system. For example, means should be available to visually or audibly cue the scientist/observer on the basis of preprocessed target signatures. These cuing signals should be made integral with a tracking telescope viewing the control station.

4.3.2.8 Improvisation

In some cases, experimental procedures can be left sufficiently flexible to permit, or perhaps demand, on-the-spot improvisision by the scientist/observer. This may involve the use of alternate procedures or equipment in the event of malfunctions of the primary procedures or equipment.

4.3.2.9 Instrument Experimentation and Repair

One of the more widely touted uses for man in space for earth observation is his potential capability of manipulating instruments for test and development. In the candidate sensor list nearly all of the sensors are off-the-shelf. None are designed to permit ready alteration. Specifically developed modular sensors and equipments would vastly improve man's ability to perform useful and effective experimentation in space.

4.3.2.10 Calibration

A prime activity for man on the Shuttle MEO may involve instrument calibration activities. For example, one sensor requires that man calibrate it by varying the timing of a detector gate until he locates the ocean surface so that an automated scan can provide soundings to various depths below the surface. Another activity of man might be in the deployment of a "standard" gray card for in-space calibration of color film cameras. Side looking radar systems may require signal level monitors and/or calibration over salt lakes and other uniform surfaces.

Man can make a significant contribution to instrument calibration efforts. He will need the appropriate displays to assist the calibration efforts.

4.3.2.11 Processor and Display Test and Evaluation

In the early Shuttle MEO flights man will make a significant contribution in the area of the onboard processor and its associated displays for scientific applications. A variety of routines should be available to permit man to process the electronic sensory data and generate test displays. The test displays should be drawn from real-data as obtained from the Skylab program so as to permit comparisons with the real-time data collected in performance of various MEO experiments. Coordination with ground experiment controllers will be required to provide verification for the onboard test in some instances and provide revised or updated processor or display routines in others.

4.3.2.12 Sensor Deployment

Sensor deployment is an area which has been considered by many commentators to be one where man can play a major role. This assumption is certainly true if the Sortie Lab is designed for these types of activities. The tentative plan to place most of the instruments on the pallet will generally constrain any substantial sensor deployment activities. If air locks can be installed in the Sortie Lab man can be used to load and unload film, change filters, change focal lengths, etc. The desired level of functional participation for man should therefore be a significant design consideration for the MEO Sortie Lab. Significant improvements in experiment accomplishment could be made if man's role were optimized by the Lab design.

4.3.2.13 Data Packaging

This role for man is very straightforward but extremely important. Photographic film must be environmentally controlled throughout its entire use cycle in order to attain high quality end results. Procedures should be established for maintaining strict handling and storage controls, and man's role will be to implement and maintain the integrity of these controls. Magnetic tapes also require reasonable packaging and handling and the scientist/observer can play a significant role in assuring the integrity of the packaging of the data.

4.3.2.14 Report Preparation

Since the scientist/observer will often be expected to be either the principal investigator or coinvestigator, it is clear that report preparation will be a manned activity both in the MEO Lab and on the ground after recovery. The MEO Lab should be provided with tools and space for report initiation.

4.3.2.15 Communication

One of the prime roles for man in Shuttle - MEO will be as a communicator. The various types of communicator roles will range from the required mission status updates to coordination with ground observer teams to disaster warnings. Since time may be of the

essence during the Sortie mission, careful consideration should be directed to means for compressing or coding the communicated data, e.g., by design of appropriate languages. Equipment should be provided to permit emergency transmission direct to any point on earth.

Communication in its various forms is an important function to be performed by man in Shuttle MEO. Procedures, equipment, language, etc. should be carefully reviewed.

How do these roles apply to the candidate Priority I Pollution Mission? Figure 4-6 presents a summary matrix which offers an estimate of man's role on the basis of a three-level code. Notice that man is essential in all of the candidate experiments. Obviously, this is not an unexpected result; however, the performance of man's essential role depends on the provision for various tools and certain design considerations as mentioned in each of the functional discussions.

4.3.3 The Optimum Use of Man in Shuttle MEO

We consider two possible extremes of experiment philosophy, viz., (a) We put a man with a camera, some technical background, intellectual curiosity, and a keen "eyeball" in Shuttle MEO, and instruct him to observe, or (b) we put man and a large number of automated sensors at opposite ends of the spacecraft, leaving man the function of monitoring the orientation of the spacecraft, perhaps turning sensors on and off, and supervising data recovery.

The first example (a) is unaided man; the second (b) can easily be misemployed man. The concept inherent in our thinking for Shuttle MEO is that the presence of man on the mission drives the way that the experiments will be conducted. When we have a group of sensors at one end of the Shuttle and man at the other end, we must provide the means to permit man to control those instruments. Certainly automated instruments will and should fly in Shuttle MEO payloads, but the primary consideration should be "is man going to be asked to make a decision on the targets for which this sensor is to be used?" If the answer is yes, and the sensor is gimballed, means should be provided to permit man to direct the sensor.

In summary, controls and displays should be provided on Shuttle MEO to assure optimum participation in those functions listed in the previous section. If it is difficult to do this for a single sensor, then it may evolve that the sensor in question would be flown on an unmanned satellite or as a sensor test experiment on Shuttle in such a way as to offer as little interference as possible to the man-directed sensors.

4.3.4 Conclusions

Man has an important role in the Shuttle MEO Sortie Lab. Full realization of that role depends on the appreciation by the experiment designers of:

1) The performance capabilities of man in the Sortie Lab
2) The ways in which man's participation can enhance the objectives of the experiments
3) The ways that man's interest and motivation can be stimulated, and
4) The common tools, i. e., displays, viewing telescopes, processors, etc., that will be available on the Shuttle Lab.

A more in-depth look into the role of man, in relation to the design of MEO, is presented in Volume III, Section 6.0.

4.4 SHUTTLE EARTH OBSERVATION DATA HANDLING AND CONTINGENCY PLANS

The Shuttle-manned earth observatory will play a key role in research in operations which are directed towards evaluation of the resources of earth. A less publicized, but no less important, role for the Shuttle observatory would be on-call disaster assessment. Review of Shuttle MEO capabilities to perform effectively in each of the preceding roles requires consideration of the overall data handling mission/target/data interrelationships. The following sections will present a brief review of the data handling considerations for Shuttle and will examine those data handling considerations in terms of a real on-call, potential disaster situation.

4.4.1 Data Handling Mission/Target/Data Interrelationships

Figure 4-7 presents a general diagram of the overall interrelationships between types of missions, targets, and data. The missions can generally be separated into research and development types and operational types. Targets can be generally categorized as preprogrammed targets, around which the mission is planned, and targets of opportunity. Targets of opportunity can be subdivided into two classes; those that can be predicted or programmed on the basis of information gathered during the Shuttle mission, information gathered from various unmanned satellite platforms, or information transmitted by observers onboard ship or on land at any point on the globe, and those which are essentially unpredictable, such as might be observed by the astronaut during the performance of his primary mission role. In the former category of opportunity targets, the options for coverage can be assessed by ground controllers and appropriate adjustments made in mission time-lines to accommodate the proposed on-call diversion from the planned mission objectives. In the latter case, the decision to divert from the planned mission must necessarily be initiated by the scientist/observer with subsequent mission accounting and time-line update being delegated to the ground controller.

The general types of data that will be acquired during the Shuttle mission are outlined in Figure 4-6 as digital film and voice. The on-call assessment role for Shuttle will probably make use of each of these data types; however, in the case of a potential disaster assessment, emphasis will be directed to those types of data that can be transmitted to the ground for subsequent evaluation and application to the disaster situation. Currently planned sensor data handling systems for MEO, as defined by the requirements of the pollution mission, are defined in Volume III, Section 7.0.

4.4.2 Data Handling for a Forecastable Target of Opportunity

Figure 4-8 outlines the general situation; the scenario — the Shuttle MEO pollution mission is entering day six of a seven-day mission. A tropical storm, which has been tracked over several days, is developing into a hurricane off the southeastern coast of the United States — the

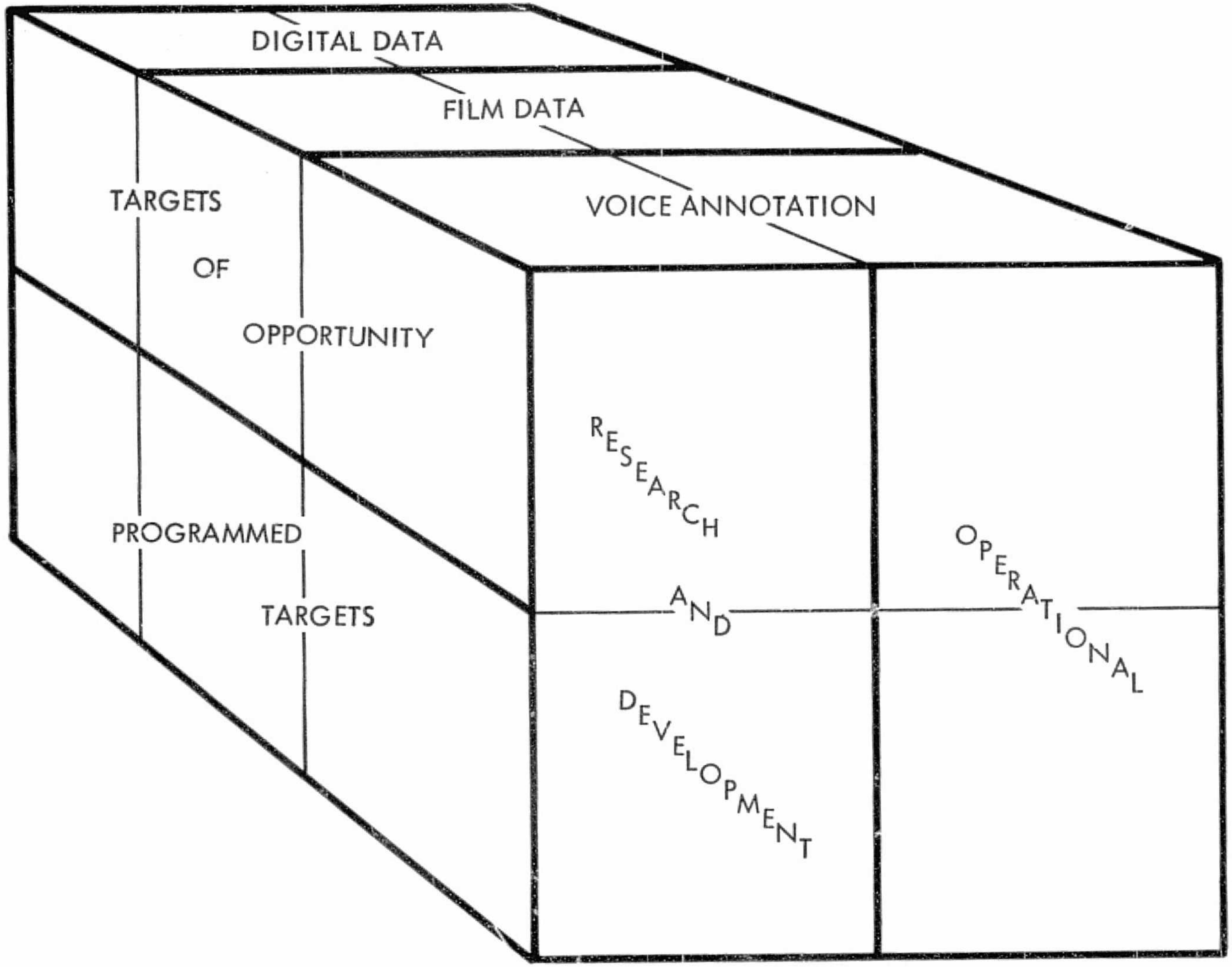


Figure 4-7. Data Handling Mission/Target/Data Inter-Relationships

requirement on Shuttle MEO: get a detailed evaluation of the developing storm as soon as possible.

SCENARIO:		
• MISSION — POLLUTION		
• TIME — BEGINNING OF DAY 6		
• SITUATION —	TROPICAL STORM IS DEVELOPING INTO A HURRICANE OFF THE SOUTH EASTERN COAST OF THE UNITED STATES.	
	A DETAILED EVALUATION IS NEEDED AS SOON AS POSSIBLE.	

Figure 4-8. Data Handling of a Forecastable Target of Opportunity

The Shuttle MEO pollution mission has a substantial number of sensors onboard. Figure 4-9 indicates which sensors can be appropriately directed toward the storm assessment role and the observables for which they are most suited. Figure 4-10 provides an overview of the appropriate Shuttle passes providing the on-call disaster assessment coverage and the distribution of ground readout station coverage available for direct transmission. Very important information could be derived about the future course of the hurricane and changes in intensity could be inferred if it were possible to transmit data on visual properties, cloud liquid water contents, sea surface temperatures, and lightning distributions during the time available on revolutions 1, 6 and 16, all providing a readout to either Corpus Christi, Texas, Cape Kennedy, Florida, or Bermuda (see Figure 4-11).

SENSORS ↓ / DESIRED OBSERVABLES →	CLOUD VISUAL AND OPTICAL PROP	CLOUD TOP TEMP/PRESSURE	CLOUD LIQ H_2O CONTENT/ DROP SIZE	ICE VS. WATER CLOUD	SEA SURFACE TEMP	SEA STATE	PRECIPITATION	VERTICAL TEMP PROFILE	LIGHTNING
TRACKING TELESCOPE	*					*			*
POINTABLE I.D. CAMERA	*								
PANORAMIC CAMERA	*								
WIDE ANGLE FRAMING CAMERA	*								
IR MULTISPECTRAL SCANNER					*				
VISIBLE RADIATION POLARIMETER		*		*		*(1)			
TIROS N ADV VERY HIGH RES RADIOMETER	*								
TIROS N OPERATIONAL VERTICAL SOUNDER								*	
PASSIVE MULTICHANNEL MICROWAVE RADIOMETER						*	*		
WIDE ANGLE VIEWER	*					*			*

(1) FROM SUN GLITTER

Figure 4-9. Pollution Mission Instruments Used to Monitor Hurricane

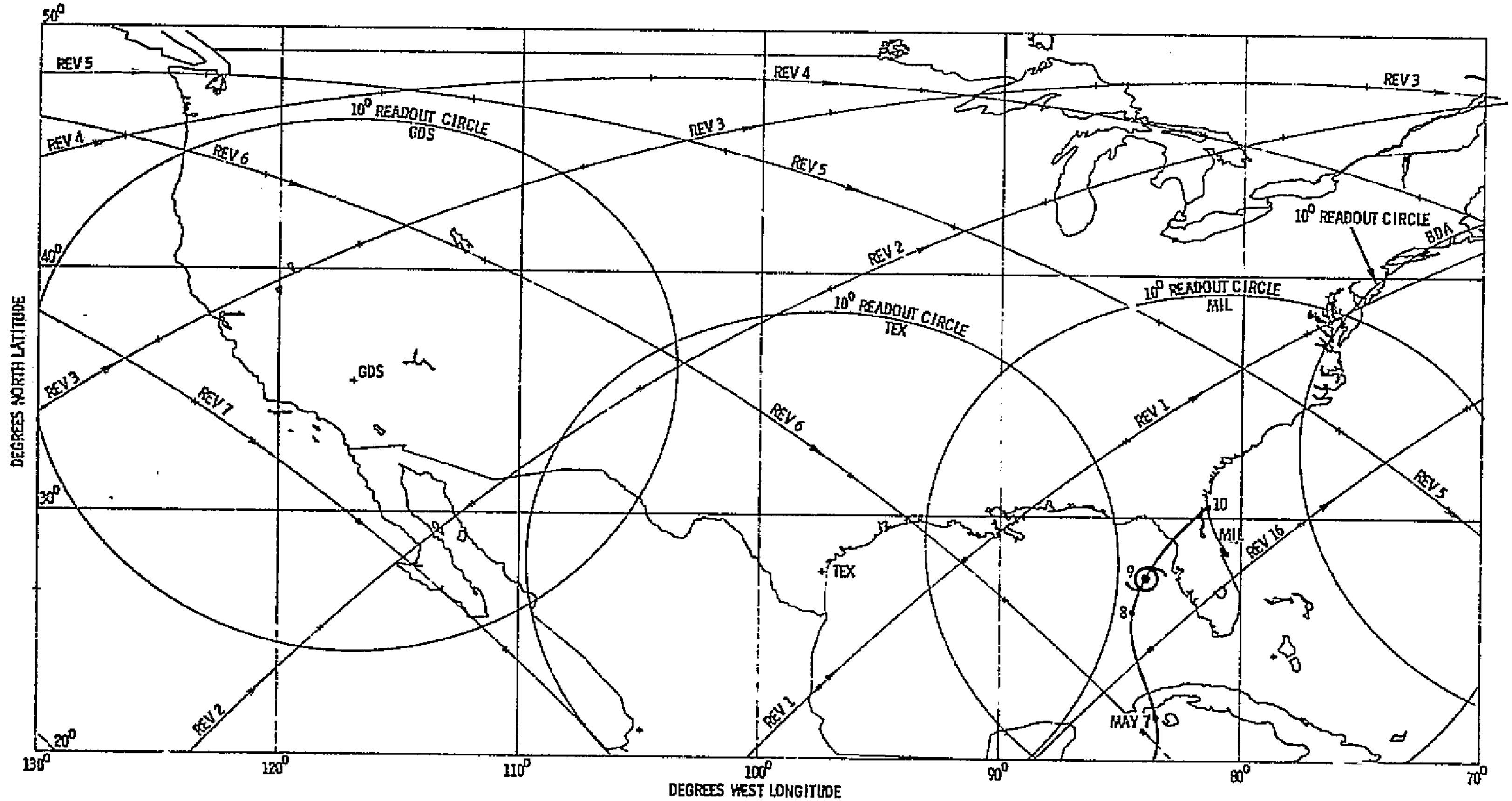


Figure 4-10. MEO Readout for Typical Day

	SENSOR	REV 1 TIME (SEC)	REV 1 DATA	REV 6 TIME (SEC)	REV 6 DATA	REV 16 TIME (SEC)	REV 16 DATA
	1	154					
	2	44					
	3	32					
	4	308					
	14	88	220 MB	88	220 MB	88	220 MB
	16	88	21.1 MB	88	21.1 MB	88	21.1 MB
TRANSMITTABLE DATA	27	3	3.4 MB			3	3.4 MB
	28	3	9 KB				
	29	3	600 KB				
	32	170					

DATA DUMP TIME (SECONDS) (ASSUMES 4 MB/S TRANSMISSION RATE)

	REV 1	REV 6	REV 16
• REQUIRED	61.3	60.3	61.1
• AVAILABLE	347.4 (MIL + BDA)	191.4 (MIL)	489 (MIL + BDA)

Figure 4-11. Data Dump for Disaster Warning and Assessment

4.4.3 Summary

The Shuttle-manned earth observatory, as configured with sensors and communications equipment for a pollution mission, is fully capable of providing on-call coverage for a range of contingency situations. In the specific case of the hurricane threatening the Florida coast, more than ample data could be provided to ground-based evaluators. The on-call capabilities for disaster assessment and short-term phenomena coverage outside of the continental United States has not yet been evaluated and may introduce problems which would require reassessment of the generally positive conclusions of this study. The primary consideration appears to be the possible need to transmit data through a tracking and data relay satellite into a location where appropriate analysis and evaluation can occur.

4.5 SHUTTLE'S ROLE IN MULTI-STAGE SAMPLING OF THE MARINE ENVIRONMENT

The data gathering capabilities of spaceborne or airborne remote sensors are creating increased interest in the possibilities of developing up to date information management systems for marine and terrestrial environments. Bright as the prospects appear to be, for terrestrial resources where the time constant of change in the objects to be mapped is large, the dynamic marine environment requires a careful review of approaches to be attempted.

Synoptic data gathering procedures are essential to survey of the marine environment. The problems introduced by the dynamic nature of the oceans lie in the necessity for temporal coordination of the data acquisition activities. The advent of the Shuttle spacecraft in the early 1980's may permit the application of techniques of multi-stage sampling from a single space platform. In the marine environment, decision processes and subsequent actions relating to a given multi-stage survey must be concerned with the dynamics of the features to be investigated. A shuttleborne, multi-stage sampling system could provide the synopticity necessary for effective survey of many of the phenomena of interest.

4.5.1 Multi-Stage Sampling Options with Shuttle

Multi-stage sampling is a process whereby subsequent samples for a resource survey are drawn as the basis of prior knowledge. In remote sensing the prior knowledge is usually obtained with observing systems having spatial or spectral resolution and/or coverage capabilities which are inferior to those used in subsequent stages. The Shuttle Manned Earth Observatory offers a capability to collect both moderate and high spatial and spectral resolution data. The data handling capability for simultaneous collection of moderate and high resolution (spatial and spectral) data for large geographic areas is not available, thus it is necessary to define an effective sampling strategy which can be guided by an on-board computer system on the basis of the real time information acquired with the moderate resolution (spatial and spectral) sensors.

An effective multi-stage sampling strategy which considers man's participation in an experimental role could be directed toward some really fundamental questions of "indeterminacy." Specific multi-stage

strategies might be developed to delve into the complex spatial, spectral and temporal elements that may comprise a complex imaged scene. Operational multi-stage strategies might be developed for specific resource surveys, such as forest inventory, agricultural inventory, etc.

The following discussion of a marine environment application of multi-stage sampling provides an example of a complex problem addressable from the Manned Earth Observatory.

4.5.2 A Marine Environment Application of Shuttleborne Multi-Stage Sampling

The world's oceans offer a tremendous potential for high quality animal protein for both direct human consumption and as a supplement to animal feeds. The ocean, however, is not uniformly productive; nearly 70 percent of the total harvestable proteins are produced over less than 10 percent of the total surface area of the ocean. Many of the primary production areas are geographically well located but they are only poorly understood in terms of their spatial distributions and their temporal variability. Some areas of potential high productivity, in the equatorial regions in particular, are not well known.

The time constants of the physical and biological processes which drive areas of high production are reasonably well-suited to a sampling rationale utilizing observations from unmanned spacecraft. Sampling periods shorter than phenomena duration will provide first order selection criteria for use in a multi-stage sampling design. Following review of the unmanned satellite observations, sample areas can be defined and subsampling units indicated on a grid on which the Shuttle suborbital track has been defined. Some level of stratification can be considered if there is sufficient background knowledge on the general variability in productivity as defined by the low resolution unmanned satellite image. Regardless of how the unmanned observations are partitioned, the subsequent sub-units should be of a size that is readily associated with the fields of view of the sampling sensors on the Shuttle. The primary problem which attends the marine survey case and is generally not applicable to the terrestrial phenomena situation is the necessity to differentiate between the spectral modifications introduced into the backwelling spectrum by the presence of living and non-living scatterers. Living, chlorophyll-containing microscopic algae form the first trophic level, or basic food

source, for nearly all surface pelagic commercial species. The non-living particulate matter in the water can produce similar signatures that may or may not relate to the distribution of chlorophyll. Thus, we are faced with the necessity for multi-stage sampling of spectral characteristics as well as spatial characteristics. In the current experimental programs, directly related to commercial fisheries, aircraft flying at mid-altitude carrying multi-spectral scanners and cameras have been used to further delineate the spectrally significant areas from the spectrally insignificant areas within the spatial distributions mapped from the ERTS-1 satellite. The Shuttle era marine resource survey system could both compliment such aircraft flights in regions where they can be readily deployed and supplement such aircraft in those areas, and at those times, when their deployment would be logistically difficult. Thus, the shuttleborne marine resource survey system could fulfill several roles presently requiring multiple platforms. Moderate resolution, moderate scale coverage could be utilized from Shuttle to provide stratifications of the spatial distributions of those signatures associated with living and those associated with non-living scatterers. High resolution, large scale photography, covering approximately six nautical miles at nadir, could provide a final detailed delineation of the actual areas of highest productivity, if associated with high spectral resolution data from a multispectral scanner.

4.5.3 Summary

A shuttleborne marine resource survey system in the 1980's is well within the feasible state of the art. Implementation of such a system, both for an overall survey and for deployment of surface vessels for either research purposes or harvesting purposes, will require:

- The development of improved techniques for extracting more reliable information on the marine resource from spaceborne remotely-sensed data.
- Development of effective sampling strategies which are directed in real time by an onboard computer system.
- Development of predictive models to translate chlorophyll information to fishery production information.

Information gathered by a shuttleborne resource survey system could provide the data necessary to establish reliable, versatile resource information system applicable to large, global ocean areas and useful within a marine resource information system.

5.0 LOW-COST MISSIONS

The 29 sensor pollution reference mission discussed in Sections 3.0 and 4.0 is a sophisticated, complex and costly mission which taxes the capabilities of the Shuttle. As a design driver it showed what the mission requirements would be for a most ambitious mission which attempted to satisfy all of the experiment requirements. After re-evaluating this mission, several questions arose. Since AESOP initially required experiment prioritization, why not reduce the mission to the first priority experiments? Are all 29 sensors equally important or do some obtain correlative and supplementary data? These questions led to the development of a "Low-Cost" definition rationale which, when applied to the pollution reference mission, reduced its cost and complexity and resulted in a low-cost pollution reference mission which is typical of early Shuttle Sortie missions. Because the low-cost mission is a reduced version of the initial mission, the initial mission is referred to as the "Baseline" mission. This terminology is carried through the remaining report volumes.

In this section, a tentative low-cost definition rationale will be described and applied to the baseline pollution reference mission. The low-cost and baseline versions of the pollution reference mission will be compared in terms of design in Volume III and in terms of costs in Volume IV. The first portion of the rationale is also applied to the other reference missions.

5.1 TENTATIVE LOW-COST DEFINITION RATIONALE

An overview of the definition rationale is shown in Figure 5-1. The three level experiment prioritization is identical to the one used to generate an input to AESOP (see Section 3.2.3.3). The experiment prioritization within each of the nine reference missions is shown in Table 5-1. Only the first priority experiments were considered in the low-cost mission.

The experiment sensors were prioritized into three levels:

- Mandatory — Data or use of instrument mandatory for execution of experiment.
- Valuable — Data is important for the execution of the experiment.
- Useful — Data of value, but not crucial for the execution of the experiment.

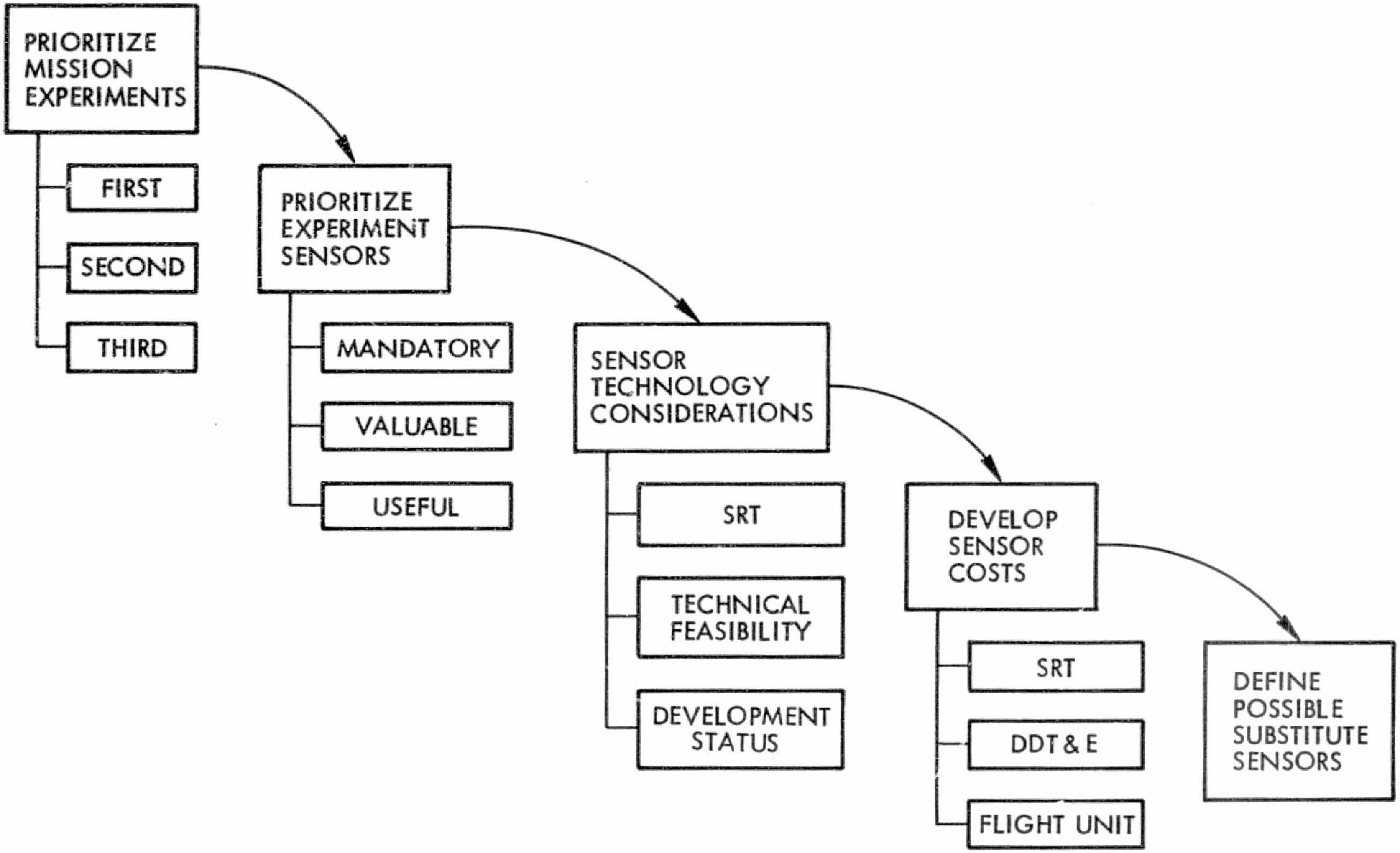


Figure 5-1. Low-Cost Mission Definition Rationale

Table 5-1. Experiment Prioritization by Reference Mission

Experiment	Pollution 1	Envir Impact 2	Ocean/Met 3	Spring 4	Summer 5	Low Altitude 6	Winter 7	Autumn 8	High Latitude 9
01	1		2						
02							1		1
03				1					
04						2	2		
05			1					2	
06			2					2	
M1					3				2
M2	3				1				
M3			2		1	2			
M4	1		1		2			2	
M5					1	1		1	1
M6			1				3		
AFR1				1	1		1		
AFR2				1				1	
AFR3	3	1	1	1		2			3
AFR4		1	2	1					
G1					1	1		2	
G2	2					3	1		
G4	2			2		1		2	1
H1				1		1	3		
H2				1					
H3		2		1		1			
H4			1				3		1
E1		1		3	1	2	2	3	
E2	1	1							
E3		1							
OT1					1	3			
OT2	2	3		2	3	1	2	1	
OT3	2	2	3	1	3		2	2	

The sensor priorities for each of the Level 1 experiments are shown in Tables 5-2 and 5-3.

The developmental status of the sensors which have been identified as candidates for the Baseline Pollution mission is summarized in Tables 5-4 and 5-5. Of the 29 sensors, two have been proven in space flight, 14 have been partially developed, primarily under the Advanced Applications Flight Experiment (AAFE) program, and development of the remaining 13 remains to be initiated.

With respect to the seven air pollution sensors and the laser altimeter/scatterometer, the technical feasibility is questionable and supporting research and technology is required. All of the seven proposed air pollution sensors have been partially developed, primarily under the AAFE program. However, in all cases additional work is required to demonstrate the feasibility of obtaining the desired measurements of atmospheric constituents or pollutants from orbit by demonstration in aircraft, balloon, or Small Applications Technology Satellite test vehicles. The feasibility of using a laser to profile the depth of plankton in ocean water remains to be proved and the hardware has to be developed.

Sensor costs were obtained for the following:

- Supporting Research and Technology (SR&T)
- Design, Development, Test and Engineering (DDT&E)
- Fabrication of flight units and flight support
- Data analysis and publication.

A summary of the total sensor costs is shown in Tables 5-2 and 5-3.

Several of the sensors previously identified were second generation instruments (i.e., more sophisticated or modified versions of instruments which were currently available) or were similar to other instruments currently under development. As a result, the available instruments as well as those currently being developed were potential substitutes. Before a substitution could be made, the effect of a reduced or slightly different capability on the satisfaction of experiment objectives would have to be evaluated. In this study, possible substitute sensors were identified (see Table 5-6), but they were not used in defining a low-cost

SENSOR PRIORITIZATION
1 = MANDATORY
2 = VALUABLE
3 = USEFUL

SENSOR →	1	2	3	4	5	6	7	8	9
	TRACKING TELESCOPE	POINTABLE IDENTIFICATION CAMERA 70 mm film 11.5 cm. (4.5 in.) f.l. 185 Km (100 n.mi.) coverage 50 m resolution	PANORAMIC CAMERA 12 cm. (5 in.) film 60 cm. (24 in.) f.l. 5 m resolution	WIDE ANGLE FRAMING CAMERA 24 x 48 cm. (9 x 18 in.) film 30 cm. (12 in.) f.l. 20 m resolution	MULTISPECTRAL CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Six cameras (four B&W, color, and false color) 46 cm. (18 in.) f.l., 185 Km (100 n.mi.) coverage 25 m resolution	HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film) Six cameras (four B&W, color, and false color) 180 cm. (72 in.) f.l., 11.6 Km. (6.5 n.mi.) coverage 6 m resolution	MULTIRESOLUTION FRAMING CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Three cameras, false color film only 46, 92, 184 cm. (18, 36, 72 in.) f.l. 25, 12, 6 m resolution	HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER 30/60 m resolution (20 Spectral Bands)	LWIR SPECTROMETER (6.2 - 15.5μ, 0.4 - 2.4μ)
FUNDING REQUIREMENT (R.O.M.) ($K)	7,250	850	2,039	4,800	4,100	2,960	3,100	10,000	6,800
O1 REGIONAL WATER POLLUTION EXPERIMENT (S.F. Bay)	1	1			1	1			
O2 SEA ICE MAPPING	1	1	1	1					
O3 PLANKTON PROFILING/COASTAL BATHYMETRY MEASUREMENTS	1	1			1				
O4 UPWELLING AREA MAPPING	1	1							
O5 OCEAN WIND AND WAVE EXPERIMENT	1	1	1	1					
O6 SUN GLITTER/MOON GLITTER MEASUREMENTS	1	1							
M1 NOCTILUCENT CLOUD PATROL	1	1							
M2 STELLAR OCCULTATION TO DETERMINE ATMOS. DENSITY									
M3 GLOBAL THUNDERSTORM AND LIGHTNING ACTIVITY	1	1							
M4 AIR POLLUTION MONITORING	1	1							
M5 WEATHER MODIFICATION EXPERIMENTS – TROPICAL STORMS	1	1	1	1					
M6 ICE ON THE SOUTHERN OCEAN	1	1	1	1					
AFR1 INTERNATIONAL AGRICULTURAL EXPER. STATION MON. PROGRAM	1	1			2		1	1	
AFR2 MULTISTAGE SAMPLING OF VEGETATION RESOURCES	1	1	2	1	1		1	1	
AFR3 WILDLIFE – ECOSYSTEM STUDIES	1	1			1		1	2	
AFR4 WINTER DAMAGE ASSESSMENT IN FOREST LAND	1	1	2	1			1		
G1 RAPID GEOLOGIC RECONNAISSANCE MAPPING	1	1	1	1	2		1	1	1
G2 COASTAL GEOLOGY AND GEOMORPHIC PROCESSES	1	1	2	2	2		1	1	2
G3 REDUCED GRAVITY EXPERIMENTS/DEMONSTRATIONS IN GEOLOGY									
G4 GEOLOGIC AND TOPOGRAPHIC MAPPING OF MOUNTAINOUS AREAS OF THE WORLD	1	1	2	2	2		1	1	2
H1 GROUND WATER DISCHARGE AND MAPPING	1	1	1	1	2	1		1	
H2 MAPPING GROUND STATE – FROZEN OR NOT	1	1	2	2	3	3	2	1	
H3 SOIL MOISTURE MAPPING TECHNIQUE DEVELOPMENT	1	1	2	2	3	3	2	1	
H4 SNOW AND ICE MONITORING STUDY	1	1	1	1	3			1	
H5 INTERNATIONAL SEASONAL STANDING WATER SURVEY	1	1	1	1					
E1 MONITORING EFFECT OF CHANGING LAND USE PATTERNS ETC.	1	1	2	2	3		1	3	
E2 LAKE EUTROPHICATION, ASSESSMENT OF MAN'S ROLE	1	1			2	2	1	1	
E3 WATER USE PATTERN – IRRIGATION	1	1	2	2	3		1	1	
OT1 ORTHOGRAPHIC MAP CONSTRUCTION FOR DEVELOPING COUNTRIES	1	1	1	1	2		1		
OT2 INTERNATIONAL DEVELOPMENT PROJECT PRE-FEASIBILITY ANALYSIS	1	1	2	2	2		1		
OT3 INTERNATIONAL METROPOLITAN AREA BIENNIAL UPDATE PROGRAM	1	1	2	2			1		

Table 5-2. Sensor Prioritization by Experiment and Sensor Funding Requirements (R.O.M.)

1	2	3	4	5	6	7	8	9	10A	10B	11A	11B	12	13	14	15
	POINTABLE IDENTIFICATION CAMERA 70 mm film 11.5 cm. (4.5 in.) f.l. 185 Km (100 n.mi.) coverage 50 m resolution	PANORAMIC CAMERA 12 cm. (5 in.) film 60 cm. (24 in.) f.l. 5 m resolution	WIDE ANGLE FRAMING CAMERA 24 x 48 cm. (9 x 18 in.) film 30 cm. (12 in.) f.l. 20 m resolution	MULTISPECTRAL CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Six cameras (four B&W, color, and false color) 46 cm. (18 in.) f.l., 185 Km (100 n.mi.) coverage 25 m resolution	HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film) Six cameras (four B&W, color, and false color) 180 cm. (72 in.) f.l., 11.6 Km. (6.5 n.mi.) coverage 6 m resolution	MULTIRESOLUTION FRAMING CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Three cameras, false color film only 46, 92, 184 cm. (18, 36, 72 in.) f.l. 25, 12, 6 m resolution	HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER 30/60 m resolution (20 Spectral Bands)	LWIR SPECTROMETER (6.2 - 15.5 μ, 0.4 - 2.4 μ)	WIDEBAND SYNTHETIC APERTURE RADAR (WBSAR) (Wide Coverage, Low Resolution Mode)	WIDEBAND SYNTHETIC APERTURE RADAR (WBSAR) (Medium Coverage, High Resolution Mode)	MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (Medium Coverage, Low Resolution Mode)	MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (Narrow Coverage, High Resolution Mode)	LASER ALTIMETER/SCATTEROMETER	VISIBLE IMAGING SPECTROMETER (Ocean Color Measurement)	IR MULTISPECTRAL MECHANICAL SCANNER (Ocean Surface Temperature Measurement)	HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER (Ocean Color Measurement)
7,250	850	2,039	4,800	4,100	2,960	3,100	10,000	6,800	20,200	20,200	20,200	20,200	3,900	2,400	3,100	2,100
1 1 1 1 1 1	1 1 1 1 1 1	1 1	1 1	1 1	1				1	1 1			2 2 1 1	1 1 1	2 3 1	1 1
1 1 1 1 1	1 1 1 1 1	1 1	1 1						1				2		2 3	
1 1 1 1	1 1 1 1	2 2	1 1	2 1 1		1 1 1 1	1 1 2					1 1				
1 1 1	1 1 1	1 2 2	1 2 2	2 2 2		1 1 1	1 1 1	1 2 2			1 2 2					
1 1 1 1 1	1 1 1 1 1	1 2 2 1 1	1 2 2 1 1	2 3 3 3	1 3 3	2 2	1 1 1 1		2	2	1 1		2			
1 1 1	1 1 1	2 2	2 2	3 2 3	2	1 1 1	3 1 1					1		1		
1 1 1	1 1 1	1 2 2	1 2 2	2 2		1 1 1						1				

FOLDOUT FRAME 2

SENSOR PRIORITIZATION
1 = MANDATORY
2 = VALUABLE
3 = USEFUL

SENSOR →	16 HIGH RESOLUTION IR MULTISPECTRAL MECHANICAL SCANNER (Ocean Surface Temperature Measurement)	17 GLITTER FRAMING CAMERA	18 STAR TRACKING TELESCOPE	19 UV UPPER ATMOSPHERE SOUNDER (UVUAS)	20 VISIBLE RADIATION POLARIMETER (VRP)	21 AIR POLLUTION CORRELATION SPECTROMETER	22 HIGH SPEED INTERFEROMETER (HSI)	23 CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)	24 CLOUD PHYSICS RADIOMETER (CPR)	REMOTE GAS FILTER CORRELATION ANALYZER (RGFCA)
FUNDING REQUIREMENT (R. O. M.) ($K)	3,100	2,200	1,720	855	2,200	1,050	5,150	1,290	2,800	
O1 REGIONAL WATER POLLUTION EXPERIMENT (S. F. Bay)	2									
O2 SEA ICE MAPPING					2					
O3 PLANKTON PROFILING/COASTAL BATHYMETRY MEASUREMENTS										
O4 UPWELLING AREA MAPPING	1									
O5 OCEAN WIND AND WAVE EXPERIMENT		2								
O6 SUN GLITTER/MOON GLITTER MEASUREMENTS		1								
M1 NOCTILUCENT CLOUD PATROL					1					
M2 STELLAR OCCULTATION TO DETERMINE ATMOS. DENSITY			1							
M3 GLOBAL THUNDERSTORM AND LIGHTNING ACTIVITY										
M4 AIR POLLUTION MONITORING				1	1	1	1	1		
M5 WEATHER MODIFICATION EXPERIMENTS – TROPICAL STORMS									1	
M6 ICE ON THE SOUTHERN OCEAN										
AFR1 INTERNATIONAL AGRICULTURAL EXPER. STATION MON. PROGRAM										
AFR2 MULTISTAGE SAMPLING OF VEGETATION RESOURCES										
AFR3 WILDLIFE – ECOSYSTEM STUDIES										
AFR4 WINTER DAMAGE ASSESSMENT IN FOREST LAND										
G1 RAPID GEOLOGIC RECONNAISSANCE MAPPING										
G2 COASTAL GEOLOGY AND GEOMORPHIC PROCESSES										
G3 REDUCED GRAVITY EXPERIMENTS/DEMONSTRATIONS IN GEOLOGY										
G4 GEOLOGIC AND TOPOGRAPHIC MAPPING OF MOUNTAINOUS AREAS OF THE WORLD										
H1 GROUND WATER DISCHARGE AND MAPPING										
H2 MAPPING GROUND STATE – FROZEN OR NOT										
H3 SOIL MOISTURE MAPPING TECHNIQUE DEVELOPMENT										
H4 SNOW AND ICE MONITORING STUDY					2					
H5 INTERNATIONAL SEASONAL STANDING WATER SURVEY		1								
E1 MONITORING EFFECT OF CHANGING LAND USE PATTERNS ETC.										
E2 LAKE EUTROPHICATION, ASSESSMENT OF MAN'S ROLE										
E3 WATER USE PATTERN – IRRIGATION										
OT1 ORTHOGRAPHIC MAP CONSTRUCTION FOR DEVELOPING COUNTRIES										
OT2 INTERNATIONAL DEVELOPMENT PROJECT PRE-FEASIBILITY ANALYSIS										
OT3 INTERNATIONAL METROPOLITAN AREA BIENNIAL UPDATE PROGRAM										

FOLDOUT FRAME

Table 5-3. Sensor Prioritization by Experiment and Sensor Funding Requirements (R.O.M.)

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
GLITTER FRAMING CAMERA	STAR TRACKING TELESCOPE	UV UPPER ATMOSPHERE SOUNDER (UVUAS)	VISIBLE RADIATION POLARIMETER (VRP)	AIR POLLUTION CORRELATION SPECTROMETER	HIGH SPEED INTERFEROMETER (HSI)	CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)	CLOUD PHYSICS RADIOMETER (CPR)	REMOTE GAS FILTER CORRELATION ANALYZER (RGFCA)	ADVANCED LIMB RADIANCE INVERSION RADIOMETER (ALRIR)	TIROS-N ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)	TIROS-N OPERATIONAL VERTICAL SOUNDER (TOVS)	PASSIVE MICROWAVE RADIOMETER (PMMR)	MICROWAVE RADIOMETER/SCATTEROMETER	SFERICS RECEIVER 6 - 20, 300, 610 MHz	WIDE ANGLE VIEWER/HYDROGEN ALPHA LINE VIEWER	DATA COLLECTION SYSTEM
2,200	1,720	855	2,200	1,050	5,150	1,290	2,800	3,160	3,300	850	2,000	14,600	8,800	900	300	460
2 1			2									2	2 1 1		1 1 1 1 1 1	1 3
	1	1	1 1	1	1	1	1	1	1	2 3	3 2 3	3 1 2		1 1	1 1 1 1 1	3 2 3
															1 1 1 1	1
												3 3			1 1 1	3
1			2									1 1 2			1 1 1 1 1	3 2 3
															1 1 1	1 2
															1 1 1	

FOLDOUT FRAME 2

Table 5-4. Development Status--Experiment Sensors

NO.	TYPE	SENSOR	NEW DEVELOPMENT	PARTIALLY DEVELOPED	SPACE FLIGHT PROVEN
32	OPTICAL VIEWERS	WIDE ANGLE VIEWER	SIMILAR TO WILD NF2 NAVIGATION SIGHT		
1		TRACKING TELESCOPE		ITEK CORP	
33	RF DCS	DATA COLLECTION SYSTEM			ERTS-A
2	FILM CAMERAS	POINTABLE IDENTIFICATION CAMERA 70 MM FILM	SIMILAR TO SKYLAB S-190 (2 CAMERAS)		
3		PANORAMIC CAMERA (5 IN. FILM)			APOLLO 15-17 (ITEK)
4		WIDE ANGLE FRAMING CAMERA 24 x 48 CM. (9 x 18 IN.) FILM		ITEK CORP	
5		MULTISPECTRAL CAMERA SYSTEM 24 x 24 CM (9 x 9 IN.) FILM	TRW CONCEPT		
6		HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 MM FILM)	SIMILAR TO SKYLAB S-190		
7		MULTIRESOLUTION FRAMING CAMERA SYSTEM 24 x 24 CM (9 x 9 IN.) FILM	TRW CONCEPT		
8	MULTISPECTRAL IMAGING LINE SCANNER	HIGH RESOLUTION WIDEBAND MULTI-SPECTRAL SCANNER (20 SPECTRAL BANDS)		SIMILAR TO SKYLAB S-192	
9	IR SPECTROMETER	LWIR SPECTROMETER (6.2 - 15.5μ, 0.4 - 2.4μ)		SIMILAR TO SKYLAB S-191	
10	SYNTHETIC APERTURE RADARS	WIDEBAND SYNTHETIC APERTURE RADAR	STUDIES IN PROGRESS AT JPL		
11		MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR	STUDIES IN PROGRESS AT JPL		
29	PASSIVE MICROWAVE	PASSIVE MICROWAVE RADIOMETER (PMMR) (5 BANDS, 4.99 - 37 GHz)	STUDIES IN PROGRESS AT NASA-GSFC		

Table 5-5. Development Status--Experiment Sensors

NO.	TYPE	SENSOR	NEW DEVELOPMENT	PARTIALLY DEVELOPED	SPACE FLIGHT PROVEN
12	LASER	LASER ALTIMETER/SCATTEROMETER	TRW CONCEPT		
13	IMAGING SPECTROMETERS (WATER POLLUTION)	VISIBLE IMAGING SPECTROMETER		TRW (AAFE)	
15		HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER		TRW (AAFE)	
14	IMAGING IR RADIOMETERS (WATER POLLUTION)	IR MULTISPECTRAL MECHANICAL SCANNER	TRW CONCEPT		
16		HIGH RESOLUTION IR MULTISPECTRAL SCANNER	TRW CONCEPT		
18	STAR TRACKER	STAR TRACKING TELESCOPE	UNIV MICH CONCEPT		
20	AIR POLLUTION SENSORS	VISIBLE RADIATION POLARIMETER		UCLA (AAFE) TRW(IR&D)	
19		UV UPPER ATMOSPHERE SOUNDER		UNIV OF COLO (AAFE)	
26		ADVANCED LIMB RADIANCE INVERSION RADIOMETER		NCAR (AAFE)	
23		CARBON MONOXIDE POLLUTION EXPERIMENT		GE (AAFE & IR&D)	
21		AIR POLLUTION CORRELATION SPECTROMETER		BARRINGER RESEARCH	
22		HIGH SPEED INTERFEROMETER		JPL (AAFE & OMSF)	
25		REMOTE GAS FILTER CORRELATION ANALYZER		SCIENCE APPLIC (AAFE)	
27	IR RADIOMETERS (CORRELATIVE DATA - AIR POLLUTION)	TIROS-N ADVANCED VERY HIGH RESOLUTION RADIOMETER		ITT (CONTRACT INITIATED)	
28		TIROS-N OPERATIONAL VERTICAL SOUNDER	UNDER STUDY (NOAA)		

NO.	SENSOR	ALTERNATE SENSOR	COMMENTS
1	TRACKING TELESCOPE	NONE	USED FOR HIGH RESOLUTION TELEPHOTO SIGHTINGS BY ASTRONAUT
2	POINTABLE IDENTIFICATION CAMERA 70 mm film	SKYLAB S-190 MULTISPECTRAL PHOTOGRAPHIC FACILITY (WITH 2-AXIS GIMBALS ADDED)	POINTABLE IDENTIFICATION CAMERA USES TWO CAMERAS. S-190 HAS SIX CAMERAS ON COMMON MOUNT.
3	PANORAMIC CAMERA (5 in. film)	NONE	--
4	WIDE ANGLE FRAMING CAMERA 24 x 48 cm. (9 x 18 in.) film	NONE	USED IN CONJUNCTION WITH PANORAMIC CAMERA FOR CARTOGRAPHIC MAPPING
5	MULTISPECTRAL CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film	NONE	--
6	HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film)	SKYLAB S-190 MULTISPECTRAL PHOTOGRAPHIC FACILITY (WITH 2-AXIS GIMBAL ADDED)	IF S-190 USED, MUST CHANGE OPTICS FROM WIDE ANGLE TO TELEPHOTO.
7	MULTIRESOLUTION FRAMING CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film	NONE	—
8	HIGH RESOLUTION WIDEBAND MULTI-SPECTRAL SCANNER 30/60 m resolution (20 Spectral Bands)	SKYLAB S-192 MULTISPECTRAL SCANNER WITH 2-AXIS GIMBAL ADDED	S-192 HAS ONLY 13 SPECTRAL BANDS. P.I. DESIRES 20 SPECTRAL BANDS.
9	LWIR SPECTROMETER ($6.2 - 15.5\mu$, $0.4 - 2.4\mu$)	SKYLAB S-191 INFRARED SPECTROMETER	--
10A	WIDEBAND SYNTHETIC APERTURE RADAR (WBSAR) (Wide Coverage, Low Resolution Mode)	DUAL FREQUENCY SYNTHETIC APERTURE RADAR (X- AND L-BAND, 3 and 26 cm.) (PROPOSED BY JPL)	--
10B	WIDEBAND SYNTHETIC APERTURE RADAR (WBSAR) (Medium Coverage, High Resolution Mode)	SAME AS 10A	--
11A	MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (Medium Coverage, Low Resolution Mode)	SAME AS 10A	MFWBSAR FREQUENCIES ARE 3, 5.5, 10 GHz. JPL DUAL FREQUENCY SAR FREQUENCIES ARE 1.15 AND 10 GHz
11B	MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (Narrow Coverage, High Resolution Mode)	SAME AS 10A	SAME AS ABOVE (11A)
12	LASER ALTIMETER/SCATTEROMETER	NASA-MSFC LED-PUMPED Nd:YAG LASER (AAFE 1971) IS A POSSIBILITY	--
13	VISIBLE IMAGING SPECTROMETER	OCEANIC SCANNING SPECTROPHOTOMETER FOR EOS (WARREN HOVIS, NASA-GSFC)	EOS OSS IS IN R&D STAGE
14	IR MULTISPECTRAL MECHANICAL SCANNER (Ocean Surface Temperature Measurement)	EOS SEA SURFACE TEMPERATURE IMAGING RADIOMETER	--
15	HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER	OCEANIC SCANNING SPECTROPHOTOMETER FOR EOS (WARREN HOVIS, NASA-GSFC) WITH TELEPHOTO LENS	EOS OSS IS IN R&D STAGE
16	HIGH RESOLUTION IR MULTISPECTRAL SCANNER (Ocean Surface Temperature Measurement)	EOS SEA SURFACE TEMPERATURE IMAGING RADIOMETER MODIFIED FOR NARROW FOV (TELEPHOTO OPTICS, POINTABLE)	USE OF EOS SSTIR WILL REQUIRE MAJOR REDESIGN FOR NARROW FOV.
17	GLITTER FRAMING CAMERA	WESTINGHOUSE SEC VIDICON CAMERA FROM APOLLO PROGRAM	--
18	STAR TRACKING TELESCOPE	NONE	--
19	UV UPPER ATMOSPHERE SOUNDER (UVUAS)	NONE	--

Table 5-6. MEO Sensor Payload and Alternate Sensors

	Resolution Mode)		
11B	MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (Narrow Coverage, High Resolution Mode)	SAME AS 10A	SAME AS ABOVE (11A)
12	LASER ALTIMETER/SCATTEROMETER	NASA-MSFC LED-PUMPED Nd:YAG LASER (AAFE 1971) IS A POSSIBILITY	--
13	VISIBLE IMAGING SPECTROMETER	OCEANIC SCANNING SPECTROPHOTOMETER FOR EOS (WARREN HOVIS, NASA-GSFC)	EOS OSS IS IN R&D STAGE
14	IR MULTISPECTRAL MECHANICAL SCANNER (Ocean Surface Temperature Measurement)	EOS SEA SURFACE TEMPERATURE IMAGING RADIOMETER	--
15	HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER	OCEANIC SCANNING SPECTROPHOTOMETER FOR EOS (WARREN HOVIS, NASA-GSFC) WITH TELEPHOTO LENS	EOS OSS IS IN R&D STAGE
16	HIGH RESOLUTION IR MULTISPECTRAL SCANNER (Ocean Surface Temperature Measurement)	EOS SEA SURFACE TEMPERATURE IMAGING RADIOMETER MODIFIED FOR NARROW FOV (TELEPHOTO OPTICS, POINTABLE)	USE OF EOS SSTIR WILL REQUIRE MAJOR REDESIGN FOR NARROW FOV.
17	GLITTER FRAMING CAMERA	WESTINGHOUSE SEC VIDICON CAMERA FROM APOLLO PROGRAM	--
18	STAR TRACKING TELESCOPE	NONE	--
19	UV UPPER ATMOSPHERE SOUNDER (UVUAS)	NONE	--
20	VISIBLE RADIATION POLARIMETER (VRP)	NONE	--
21	AIR POLLUTION CORRELATION SPECTROMETER	NONE	--
22	HIGH SPEED INTERFEROMETER (HSI)	NONE	--
23	CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)	NONE	--
24	CLOUD PHYSICS RADIOMETER (CPR)	NONE	--
25	REMOTE GAS FILTER CORRELATOR ANALYZER (RGFCA)	NONE	--
26	ADVANCED LIMB RADIANCE INVERSION RADIOMETER (ALRIR)	NONE	--
27	TIROS-N ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)	NONE	--
28	TIROS-N OPERATIONAL VERTICAL SOUNDER (TOVS)	NONE	--
29	PASSIVE MICROWAVE RADIOMETER (PMMR) (5 BANDS, 4.99 - 37 GHz)	NIMBUS E (19.35 GHz) --AEROJET CORP. NIMBUS F (37.5 GHz) --AEROJET CORP. NIMBUS E MICROWAVE SOUNDER (JPL) (5 Bands, 22-59 GHz) NIMBUS F SCANNING MICROWAVE SOUNDER (JPL) (5 Bands, 22-55 GHz)	USE OF ALTERNATE SENSORS WILL NOT SATISFY SCIENTIFIC OBJECTIVES OF PMMR DUE TO USE OF FEWER OR DIFFERENT FREQUENCY BANDS.
30	MICROWAVE RADIOMETER/ SCATTEROMETER (37 GHz)	SHUTTLE IMAGING MICROWAVE SYSTEM NASA-MSC CONTRACT NAS7-100 RD4-219 to JPL	PASSIVE SYSTEM ONLY. REQUIRES DEPLOYMENT OF 30 FT. PARABOLIC ANTENNA. SIX BANDS (0.3 - 94 GHz). CURRENTLY IN DEFINITION PHASE.
31	SFERICS RECEIVER 6 - 20, 300, 610 MHz	NONE	--
32	WIDE ANGLE VIEWER/HYDROGEN ALPHA LINE VIEWER	NONE	--
33	DATA COLLECTION SYSTEM	NONE	--

pollution reference mission. In the next phase of the study when the definition rationale is finalized, the substitute sensors will be given serious consideration.

5.2 LOW-COST POLLUTION MISSION

5.2.1 Application of Low-Cost Definition Rationale

The experiment prioritization resulted in the groups shown in Table 5-7. Of the 29 pollution reference mission sensors, 24 are required by the first priority experiments. The sensors that were eliminated include: the mapping sensors 3, 4, and 11; 9, which is only used in the geology experiments; and 18, which is only required by Experiment M2.

Table 5-7. Experiment Prioritization

Priority	Experiment	
1	O1	Regional water pollution monitoring
	M4	Air pollution monitoring
	E2	Lake Eutrophication studies
2	G2	Coastal geology and geomorphic processes
	G4	Geologic and topographic mapping
	OT3	Urban survey
	OT2	International development project
3	M2	Stellar occultation
	AFR3	Wildlife-ecosystem studies

The application of sensor prioritization eliminated another five sensors:

- 15 and 16 are high-resolution versions of sensors 13 and 14.
- 19 is limited to the upper atmosphere/single constituent only.
- 27 and 28 are only correlative sensors. Measurements can be obtained from other programs.

Because the technical feasibility of the laser altimeter/scatterometer (12) is questionable and the development is a long way off, it was eliminated. The elimination of this instrument does not damage the overall objectives of experiments O1 and E2.

The remaining radar (10B) ($20. 2M) and the passive microwave radiometer (29) ($14. 6M) were eliminated primarily because of costs. Sensor 10B was only required by experiment O1 and its elimination did not damage the experiment's integrity. In addition to being costly, Sensor 29 was primarily used for correlative support. The resulting number of low-cost pollution mission sensors was 16.

A review of the other baseline pollution reference mission experiments in terms of the 16 low-cost mission sensors shows that all the mandatory experiment sensors remain except 18, which is the only sensor required by Experiment M2. Therefore, the low-cost mission can include all but one of the baseline experiments. A comparison of low-cost and baseline versions of the pollution reference mission in terms of experiments and sensors is shown in Figure 5-2.

In addition to the low-cost mission sensors discussed above, consideration might be given to non-mandatory sensors that have a high-availability and a low-cost. As shown in Figure 5-3, three of the 13 sensors not selected fall into this category.

EXPERIMENTS	
M4	AIR POLL MONITOR
O1	REG WATER POLL
E2	LAKE EUTROPHICATION
G2	COASTAL GEOL AND GEOM
OT3	URBAN SURVEY
G4	GEOL AND TOPO MAPPING
OT2	INT'L DEV PROJECT
AFR3	WILDLIFE-ECOSYSTEM
M2	STELLAR OCCULTATION

NO.	SENSORS
1	TRACKING TELESCOPE
2	POINTABLE IDENT CAMERA
3	PAN CAMERA
4	WIDE-ANGLE CAMERA
5	MS CAMERA
6	HIGH RES MS CAMERA
7	MULTIRES CAMERA
8	HIGH RES MS SCANNER
9	LWIR SPECT
10	WIDEBAND SAR
11	MULTIFREQ WIDEBAND SAR
12	LASER ALT/SCAT
13	VIS IMAG SPECT
14	IR MS MECH SCANNER
15	HIGH RES VIS IMAG SPECT
16	HIGH RES IR MS SCANNER
18	STAR TRACK TELESCOPE
19	UV UPPER ATMOS SOUNDER
20	VIS RAD POLARIMETER
21	AIR POLL CORREL SPECT
22	HIGH SPEED INTERFER
23	CO_2 POLL EXPT
25	GAS FILTER CORREL
26	ADV LIMB RAD INVERS RAD
27	TIROS-N ADV VERY HI RES RAD
28	TIROS-N OPER VERT SOUNDER
29	PASSIVE MICROWAVE RAD
32	WIDE ANGLE/H-α VIEWER
33	DATA COLLECT SYSTEM

LOW COST MISSION

Figure 5-2. Low-Cost Pollution Reference Mission

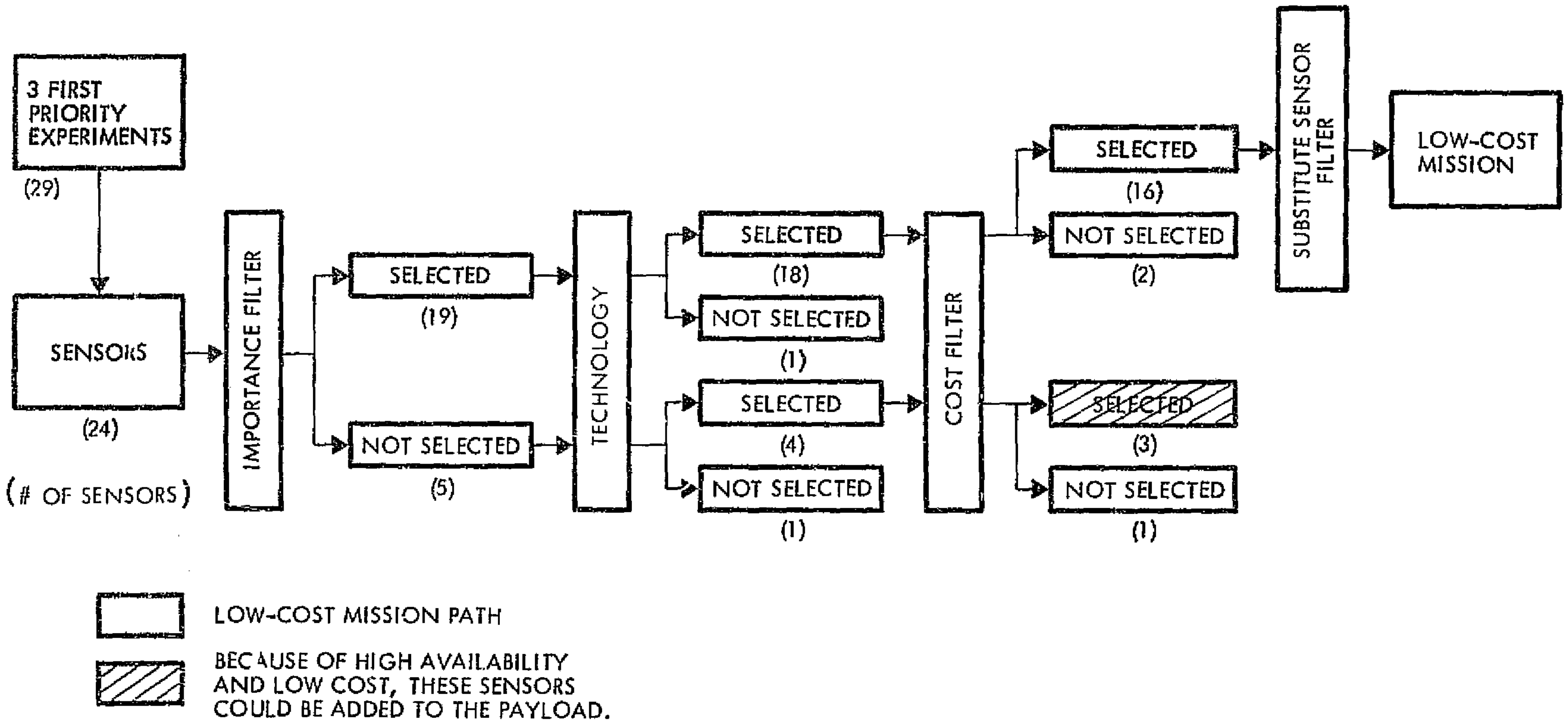


Figure 5-3. Low-Cost Pollution Reference Mission Definition

5.2.2 Comparison Between Low-Cost and Baseline Pollution Reference Mission

The application of the low-cost mission definition rationale to the Pollution Reference mission resulted in a substantial change in the number of sensors, power requirements and sensor costs. The orbit and data requirements remained essentially the same (see Figure 5-4).

The elimination of experiment M2 did not affect the selection of a Pollution Reference mission orbit because it did not require any targets on the earth's surface. Since the 13 sensors not considered in the low-cost version were low data rate instruments, the mission data requirement remained essentially unchanged. (Sensors 8 and 14, 200 MB/S and 7 MB/S respectively, were the primary data drivers and they were included in the low-cost version.) The elimination of the two radars (Sensors 10B and 11A, 2400W and 2300W respectively), had a substantial effect on the power requirements. The peak power required was reduced by 63 percent to 3.7 kw and the average power required was reduced by 65 percent to 1 kw. The total cost for sensors was also substantially affected by the radars ($32M)* as well as the microwave radiometer (Sensor 29, $11.6M)*. The elimination of these sensors, as well as the other ten, reduced the total cost of sensors by 63 percent to $36M.* A more detailed comparison in terms of subsystem requirements, preliminary design and costs can be found in Volumes III and IV.

* Costs include DDT&E and fabrication of first flight unit.

BASELINE VERSION		LOW-COST VERSION
9/29	EXPERIMENTS/ SENSORS	8/16
48 DEG/183 N MI	ORBIT	48 DEG/183 N MI
3.2×10^{13} BITS	DATA REQ	3.2×10^{13} BITS
PEAK: 10 KW AVERAGE: 2.9 KW	POWER REQ	PEAK: 3.7 KW AVERAGE: 1 KW
$ 98 MILLION	SENSOR COSTS	$36 MILLION

Figure 5-4. Pollution Reference Mission
Comparison Between Baseline and Low-Cost Versions

5.3 ADDITIONAL LOW-COST MISSIONS

In Section 5.1 the experiment prioritization was applied to all nine reference missions and the sensor prioritization was applied to all 33 sensors. By considering only the first priority experiments within each reference mission and the mandatory sensors associated with these experiments, the inital effect of the tentative low-cost mission definition rationale on Missions 2-9 can be observed. Results are shown in Tables 5-8 and 5-9. The sensor costs do not include a spare unit or data analysis and publication. If a sensor was mandatory in one or more experiments it was selected as a low-cost mission sensor. The number of sensors and the total cost of every reference mission except spring was reduced substantially (see Table 5-10). The baseline low-cost versions of the spring reference mission utilized approximately the same number of sensors because there were an exceptionally large number of Level 1 experiments.

Table 5-8. First Priority Experiments in Missions 2 through 9

Experiment \ Mission	2 Envir. Impact	3 Ocean/Met.	4 Spring	5 Summer	6 Low Latitude	7 Winter	8 Autumn	9 High Latitude
O1								
O2						X		X
O3			X					
O4								
O5		X						
M1								
M2				X				
M3				X				
M4		X						
M5				X	X		X	
M6		X						X
AFR1			X	X		X		
AFR2			X				X	
AFR3	X	X	X					
AFR4	X		X					
G1				X	X			
G2						X		
G4					X			X
H1			X		X			
H2			X					
H3			X		X			
H4		X						X
H5			X					X
E1	X							
E2	X			X				
E3	X							
OT1				X				
OT2					X		X	
OT3			X					

Table 5-9. Mandatory Sensors in Level 1 Environment

Sensor	Experiment																								
	02	03	05	M2	M3	M4	M5	M6	AFR1	AFR2	AFR3	AFR4	G1	G2	G4	H1	H2	H3	H4	H5	E1	E2	E3	OT1	OT2	OT3
1	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	X		X				X	X					X	X	X	X			X	X				X	X	X
4	X		X				X	X		X		X	X	X	X	X			X	X				X	X	X
5		X								X	X															
6																X										
7									X	X	X	X	X	X	X						X	X	X	X	X	X
8									X	X			X	X	X	X	X	X	X			X	X			
9													X	X	X											
10	X		X					X																		
11									X	X			X	X	X				X	X	X				X	
12		X	X												X											
13		X																				X				
14																										
15	Not Mandatory for Any Level 1 Experiments																									
16																										
17																				X						
18				X																						
19						X																				
20						X																				
21						X																				
22						X																				
23						X																				
24							X																			
25						X																				
26						X																				
27																										
28	Not Mandatory for Any Level 1 Experiments																									
29							X										X	X								
30			X																							
31					X		X																			
32	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
33											X										X					

Table 5-10. Comparison of Baseline and Preliminary Low-Cost Reference Missions

Mission Priority		2	3	4	5	6	7	8	9
Mission Emphasis		Environmental Impact	Ocean/Metorology	Spring	Summer	Low-Latitude	Winter	Autumn	High-Latitude
Number of sensors	Baseline	13	30	15	27	23	22	30	18
	Preliminary low-cost	9	18	14	13	13	10	11	13
Experiments	Baseline	8	10	13	11	12	11	10	7
	Preliminary low-cost (1st priority experiment only)	5	5	10	7	6	3	3	5
Cost of sensors ($M)	Baseline	55.2	101.0	73.9	77.5	89.2	95.5	103.7	87.9
	Preliminary low-cost	37.9	65.4	58.0	46.7	57.7	57.7	41.9	62.4

APPENDIX A

SENSOR SPECIFICATIONS

APPENDIX A

APPENDIX A

SENSOR SPECIFICATIONS

This Appendix presents the instrument specifications for the Level 1 experiments defined in the MEO report entitled "Task 1 - Experiment Selection, Definition and Documentation." The topics addressed in the Instrument Specification Sheets are as follows:

- General Description
- Performance Characteristics
- Physical Characteristics
- Platform/Data Considerations

A summary of the instrument requirements of the Level 1 experiments is shown in Table A-1.

Table

		1	2	3	4	5	6	7	8	9
		TRACKING TELESCOPE	POINTABLE IDENTIFICATION CAMERA 70 mm film 11.5 cm. (4.5 in.) f.l. 185 Km (100 n.mi.) coverage 50 m resolution	PANORAMIC CAMERA 12 cm. (5 in.) film 60 cm. (24 in.) f.l. 5 m resolution	WIDE ANGLE FRAMING CAMERA 24 x 48 cm. (9 x 18 in.) film 30 cm. (12 in.) f.l. 20 m resolution	MULTISPECTRAL CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Six cameras (four B&W, color, and false color) 46 cm. (18 in.) f.l., 185 Km (100 n.mi.) coverage 25 m resolution	HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film) Six cameras (four B&W, color, and false color) 180 cm. (72 in.) f.l., 11.6 Km. (6.5 n.mi.) coverage 6 m resolution	MULTIRESOLUTION FRAMING CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Three cameras, false color film only 46, 92, 184 cm. (18, 36, 72 in.) f.l. 25, 12, 6 m resolution	HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER 30/60 m resolution (20 Spectral Bands)	LWIR SPECTROMETER (6.2 - 15.5 μ, 0.4 - 2.4 μ)
O1	REGIONAL WATER POLLUTION EXPERIMENT (S.F. Bay)	X	X			X	X			
O2	SEA ICE MAPPING	X	X	X	X					
O3	PLANKTON PROFILING/COASTAL BATHYMETRY MEASUREMENTS	X	X			X				
O4	UPWELLING AREA MAPPING	X	X							
O5	OCEAN WIND AND WAVE EXPERIMENT	X	X	X	X					
O6	SUN GLITTER/MOON GLITTER MEASUREMENTS	X	X							
M1	NOCTILUCENT CLOUD PATROL	X	X							
M2	STELLAR OCCULTATION TO DETERMINE ATMOS. DENSITY									
M3	GLOBAL THUNDERSTORM AND LIGHTNING ACTIVITY	X	X							
M4	AIR POLLUTION MONITORING	X	X							
M5	WEATHER MODIFICATION EXPERIMENTS – TROPICAL STORMS	X	X	X	X					
M6	ICE ON THE SOUTHERN OCEAN	X	X	X	X					
AFR1	INTERNATIONAL AGRICULTURAL EXPER. STATION MON. PROGRAM	X	X			X		X	X	
AFR2	MULTISTAGE SAMPLING OF VEGETATION RESOURCES	X	X	X	X	X		X	X	
AFR3	WILDLIFE – ECOSYSTEM STUDIES	X	X			X		X	X	
AFR4	WINTER DAMAGE ASSESSMENT IN FOREST LAND	X	X	X	X			X		
G1	RAPID GEOLOGIC RECONNAISSANCE MAPPING	X	X	X	X	X		X	X	X
G2	COASTAL GEOLOGY AND GEOMORPHIC PROCESSES	X	X	X	X	X		X	X	X
G3	REDUCED GRAVITY EXPERIMENTS/DEMONSTRATIONS IN GEOLOGY									
G4	GEOLOGIC AND TOPOGRAPHIC MAPPING OF MOUNTAINOUS AREAS OF THE WORLD	X	X	X	X	X		X	X	X
H1	GROUND WATER DISCHARGE AND MAPPING	X	X	X	X	X	X		X	
H2	MAPPING GROUND STATE – FROZEN OR NOT	X	X	X	X	X	X	X	X	
H3	SOIL MOISTURE MAPPING TECHNIQUE DEVELOPMENT	X	X	X	X	X	X	X	X	
H4	SNOW AND ICE MONITORING STUDY	X	X	X	X	X			X	
H5	INTERNATIONAL SEASONAL STANDING WATER SURVEY	X	X	X	X					
E1	MONITORING EFFECT OF CHANGING LAND USE PATTERNS ETC.	X	X	X	X	X		X	X	
E2	LAKE EUTROPHICATION, ASSESSMENT OF MAN'S ROLE	X	X			X	X	X	X	
E3	WATER USE PATTERN – IRRIGATION	X	X	X	X	X		X	X	
OT1	ORTHOGRAPHIC MAP CONSTRUCTION FOR DEVELOPING COUNTRIES	X	X	X	X	X		X		
OT2	INTERNATIONAL DEVELOPMENT PROJECT PRE-FEASIBILITY ANALYSIS	X	X	X	X	X		X		
OT3	INTERNATIONAL METROPOLITAN AREA BIENNIAL UPDATE PROGRAM	X	X	X	X			X	X	

Table A-1 MANNED EARTH OBSERVATORY (MEO)

EXPERIMENTS AND SENSORS

1 of 2

1 TRACKING TELESCOPE	2 POINTABLE IDENTIFICATION CAMERA 70 mm film 11.5 cm. (4.5 in.) f.l. 185 Km (100 n.mi.) coverage 50 m resolution	3 PANORAMIC CAMERA 12 cm. (5 in.) film 60 cm. (24 in.) f.l. 5 m resolution	4 WIDE ANGLE FRAMING CAMERA 24 x 48 cm. (9 x 18 in.) film 30 cm. (12 in.) f.l. 20 m resolution	5 MULTISPECTRAL CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Six cameras (four B&W, color, and false color) 46 cm. (18 in.) f.l., 185 Km (100 n.mi.) coverage 25 m resolution	6 HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film) Six cameras (four B&W, color, and false color) 180 cm. (72 in.) f.l., 11.6 Km. (6.5 n.mi.) coverage 6 m resolution	7 MULTIRESOLUTION FRAMING CAMERA SYSTEM 24 x 24 cm. (9 x 9 in.) film Three cameras, false color film only 46, 92, 184 cm. (18, 36, 72 in.) f.l. 25, 12, 6 m resolution	8 HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER 30/60 m resolution (20 Spectral Bands)	9 LWIR SPECTROMETER (6.2 - 15.5μ, 0.4 - 2.4μ)	10A WIDEBAND SYNTHETIC APERTURE RADAR (WBSAR) (Wide Coverage, Low Resolution Mode)	10B WIDEBAND SYNTHETIC APERTURE RADAR (WBSAR) (Medium Coverage, High Resolution Mode)	11A MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (Medium Coverage, Low Resolution Mode)	11B MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (Narrow Coverage, High Resolution Mode)	12 LASER ALTIMETER/SCATTEROMETER	13 VISIBLE IMAGING SPECTROMETER (Ocean Color Measurement)	14 IR MULTISPECTRAL MECHANICAL SCANNER (Ocean Surface Temperature Measurement)	15 HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER (Ocean Color Measurement)
X	X			X	X					X			X	X	X	X
X	X	X	X						X				X		X	
X	X			X									X	X		
X	X													X	X	X
X	X	X	X							X			X			
X	X															
X	X															
X	X															
X	X															
X	X	X	X												X	
X	X	X	X						X				X		X	
X	X			X		X	X					X				
X	X	X	X	X		X	X					X				
X	X			X		X	X									
X	X	X	X			X										
X	X	X	X	X		X	X	X			X					
X	X	X	X	X		X	X	X			X					
X	X	X	X	X		X	X	X			X		X			
X	X	X	X	X	X		X									
X	X	X	X	X	X	X	X		X							
X	X	X	X	X	X	X	X			X						
X	X	X	X	X			X				X		X			
X	X	X	X								X					
X	X	X	X	X		X	X					X				
X	X			X	X	X	X							X	X	X
X	X	X	X	X		X	X									
X	X	X	X	X		X										
X	X	X	X	X		X						X				
X	X	X	X			X	X									

		16 HIGH RESOLUTION IR MULTISPECTRAL MECHANICAL SCANNER (Ocean Surface Temperature Measurement)	17 GLITTER FRAMING CAMERA	18 STAR TRACKING TELESCOPE	19 UV UPPER ATMOSPHERE SOUNDER (UVUAS)	20 VISIBLE RADIATION POLARIMETER (VRP)	21 AIR POLLUTION CORRELATION SPECTROMETER	22 HIGH SPEED INTERFEROMETER (HSI)	23 CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)	24 CLOUD PHYSICS RADIOMETER (CPR)
O1	REGIONAL WATER POLLUTION EXPERIMENT (S.F. Bay)	X								
O2	SEA ICE MAPPING					X				
O3	PLANKTON PROFILING/COASTAL BATHYMETRY MEASUREMENTS									
O4	UPWELLING AREA MAPPING	X								
O5	OCEAN WIND AND WAVE EXPERIMENT		X							
O6	SUN GLITTER/MOON GLITTER MEASUREMENTS		X							
M1	NOCTILUCENT CLOUD PATROL					X				
M2	STELLAR OCCULTATION TO DETERMINE ATMOS. DENSITY			X						
M3	GLOBAL THUNDERSTORM AND LIGHTNING ACTIVITY									
M4	AIR POLLUTION MONITORING				X	X	X	X	X	
M5	WEATHER MODIFICATION EXPERIMENTS – TROPICAL STORMS									X
M6	ICE ON THE SOUTHERN OCEAN									
AFR1	INTERNATIONAL AGRICULTURAL EXPER. STATION MON. PROGRAM									
AFR2	MULTISTAGE SAMPLING OF VEGETATION RESOURCES									
AFR3	WILDLIFE – ECOSYSTEM STUDIES									
AFR4	WINTER DAMAGE ASSESSMENT IN FOREST LAND									
G1	RAPID GEOLOGIC RECONNAISSANCE MAPPING									
G2	COASTAL GEOLOGY AND GEOMORPHIC PROCESSES									
G3	REDUCED GRAVITY EXPERIMENTS/DEMONSTRATIONS IN GEOLOGY									
G4	GEOLOGIC AND TOPOGRAPHIC MAPPING OF MOUNTAINOUS AREAS OF THE WORLD									
H1	GROUND WATER DISCHARGE AND MAPPING									
H2	MAPPING GROUND STATE – FROZEN OR NOT									
H3	SOIL MOISTURE MAPPING TECHNIQUE DEVELOPMENT									
H4	SNOW AND ICE MONITORING STUDY					X				
H5	INTERNATIONAL SEASONAL STANDING WATER SURVEY		X							
E1	MONITORING EFFECT OF CHANGING LAND USE PATTERNS ETC.									
E2	LAKE EUTROPHICATION, ASSESSMENT OF MAN'S ROLE	X								
E3	WATER USE PATTERN – IRRIGATION									
OT1	ORTHOGRAPHIC MAP CONSTRUCTION FOR DEVELOPING COUNTRIES									
OT2	INTERNATIONAL DEVELOPMENT PROJECT PRE-FEASIBILITY ANALYSIS									
OT3	INTERNATIONAL METROPOLITAN AREA BIENNIAL UPDATE PROGRAM									

FOLDOUT FRAME

Table A-1 MANNED EARTH OBSERVATORY (MEO)

EXPERIMENTS AND SENSORS

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
		STAR TRACKING TELESCOPE	UV UPPER ATMOSPHERE SOUNDER (UVUAS)	VISIBLE RADIATION POLARIMETER (VRP)	AIR POLLUTION CORRELATION SPECTROMETER	HIGH SPEED INTERFEROMETER (HSI)	CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)	CLOUD PHYSICS RADIOMETER (CPR)	REMOTE GAS FILTER CORRELATION ANALYZER (RGFCA)	ADVANCED LIMB RADIANCE INVERSION RADIOMETER (ALRIR)	TIROS-N ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)	TIROS-N OPERATIONAL VERTICAL SOUNDER (TOVS)	PASSIVE MICROWAVE RADIOMETER (PMMR)	MICROWAVE RADIOMETER/SCATTEROMETER	SFERICS RECEIVER 6 - 20, 300, 610 MHz	WIDE ANGLE VIEWER/HYDROGEN ALPHA LINE VIEWER	DATA COLLECTION SYSTEM
	X X			X									X	X X X		X X X X X X	X X
		X	X	X X	X	X	X	X	X	X	X X	X X X	X X X		X X	X X X X X	X X X
																X X X X	X
													X X			X X X	X
	X			X									X X X			X X X X X	X X X
																X X X	X X
																X X X	

FOLDOUT FRAME 2

INSTRUMENT SPECIFICATION No. 1

SENSOR: TRACKING TELESCOPE	
General Description	
Function	High resolution view of target area--providing pointing information to other instruments.
Configuration, Major Elements	Variable magnification telescope with camera and sensor port, interchangeable filters and visual viewer. Controls and scanner for selection and tracking of target.
Development Status	Developed by Itek Corp. for Skylab B.
Performance Characteristics	
Wavelength Range	Visible 400 - 700 nano-meters
IFOV	1/2 deg. at max. magnification, 124 x; 4 deg. at min. magnification, 16 X.
Pointing FOV	+70 deg. forward, -40 deg. aft, ±75 deg. roll
Spatial Resolution	5 meters/lp at maximum magnification
Sensitivity	530 ft lamberts, 2:1 contrast
Physical Characteristics	
Size cm (in.)	Dia. 43(17), Length 278(120), Elbow 55(22)
Weight Kg (lb.)	317 Kg (700 lbs)
Power W	28 V DC, 125 watts peak, average 94 watts
Platform/Data Considerations	
Pointing Accuracy	0.1 degree
Line of Sight Rate (max.)	.07 degrees/sec
Data Output	0.66 MB/s (Angle Encoder Output Signals)
Comments:	35 mm film camera - 250 ft/cassette Gimbal Encoding: 2^{20} bits/rev. (roll), 2^{18} bits/rev. (pitch)

INSTRUMENT SPECIFICATION No. 2

SENSOR: POINTABLE IDENTIFICATION CAMERA SYSTEM (70 mm film)		
General Description		
Function	Photography of target area for identification of observables.	
Configuration, Major Elements	Two boresighted and synchronized 70 mm film cameras. 115 mm (4.5 in.) f.l. lenses. Two-axis gimballing ±28 deg. Interchangeable filters. Image motion compensation.	
Development Status	Similar to Skylab S190	
Performance Characteristics		
Wavelength Range	One camera, 0.4 - 0.7μ, Panchromatic B&W	
Spectral Resolution	One camera, 0.4 - 0.7μ, Aerial Color	
Field of View	$28^{\circ} \times 28^{\circ}$ 185 Km (100 n. mi.) from 370 Km altitude	
Spatial Resolution	50 m/line-pair (66 ℓpm lens-film AWAR, T.O.C. = 1.6/1)(1)	
Sensitivity	2.5 to 10 m. sec. shutter speed, f/2.8 to f/16 in half-stop increments.	
Physical Characteristics	**Cameras and Cassettes**	**Gimbals and Control**
Size cm (in.)	40 x 40 x 56 (16 x 16 x 22)	72 x 58 x 40 (28 x 23 x 16)
Weight Kg (lbs)	23 (50)	23 (50)
Power W	50 (av.), 80 (pk.)	30 (av.), 100 pk.)
Platform/Data Considerations		
Pointing Accuracy	1 degree	
Line of Sight Rate (max.)	IMC range 10 to 30 mR/sec, controlled to 5% accuracy	
Data Output	70 mm film, 1 frame/18 sec. for 30% overlap from orbital altitude of 370 Km (100 n. mi.)	
Comments:	IMC 10 to 30 mR/sec, 5% accuracy. Film temperature control required, 68 ±5°F. 0.1 PSI pressure required, 50% relative humidity.	

(1) PAN-X B&W film, Type 3400.

INSTRUMENT SPECIFICATION No. 3

SENSOR: PANORAMIC CAMERA (12 cm. film)	
General Description	
Function	High resolution vertical or stereo panoramic photography
Configuration, Major Elements	Rotating optic, mirrors and focal plane slit, 1-axis gimbal, film magazine (6500 ft). 600 mm (24 in.) f.1. refractive optic, f/3.5 relative aperture.
Developmental Status	Flown on Apollo 15. More than 50 units built for aircraft.
Performance Characteristics	
Wavelength Range	0.52 - 0.72μ (Achromat Lens), 0.425 - 0.9μ (Apochromat Lens)
Spectral Resolution	0.20μ , 0.475μ
Field of View	12° (along-track), 120° (cross-track)
Spatial Resolution	135 ℓpm at 2/1 T.O.C., 3404 film. 5 m/ℓ.p from H = 370 Km.
Sensitivity	Exposure interval 0.39 to 29 m sec. Automatic exposure control and forward motion compensation.
Physical Characteristics	
Size cm. (in.)	152 x 74.5 x 65 (60 x 29.3 x 25)
Weight Kg (lb.)	129 (283) space envir., 91 (200) shirtsleeve envir.
Power	234 W. (av.), 28 V. DC and 115 V, 3ϕ, 400 Hz lens temperature controlled to $\pm 5^{\circ}$F
Platform/Data Considerations	
Pointing Accuracy	0.5 degree
Line of Sight Rate (max.)	5 to 25 mR/sec (gimbal programmed for V/h)
Data Output	11.5 x 128 cm negatives, B&W, color, or color IR. Continuous stereo obtained by nodding $\pm 12.5^{\circ}$ from nadir.
Comments:	Use in conjunction with Wide Angle Framing Camera (No. 4) for mapping. Recommended for multiple use mapping and map updating.

INSTRUMENT SPECIFICATION No. 4

SENSOR:	WIDE ANGLE FRAMING CAMERA (24 x 48 cm. film)	
General Description		
Function	Planimetric and topographic surveys of the terrain.	
Configuration, Major Elements	Metric camera with 300 mm (12 in.) focal length lens. Frame size 24 x 48 cm. (9 x 18 in.) long dimension oriented along flight line to obtain overlap. Calibrated reseau for geometric reference, rotating disc (between-the-lens) shutter. Image motion compensation	
Developmental Status	Sim. equipt. operational in aircraft. Dev. for space flight req.	
Performance Characteristics		
Wavelength Range	B/W Panchromatic Film, 0.5 - 7μ	
Spectral Resolution	0.2μ	
Field of View	$41^{\circ} \times 74^{\circ}$, gimbal $\pm 28^{\circ}$ cross-track (mapping), $\pm 60^{\circ}$ (Expr. M-1)	
Spatial Resolution	60 ℓpm lens-film AWAR, TOC = 1.6/1 (20 m/ℓ-p from H = 370 Km)(1)	
Sensitivity	1 to 10 m sec. shutter speed, continuously variable. f/6.3 to f/22 in half-stop increments	
Physical Characteristics	Camera and Cassettes	Gimbals and Control
Size cm. (in.)	55 x 66 x 83 (22 x 26 x 33)	72 x 58 x 40 (28 x 23 x 16)
Weight Kg (lbs.)	68.5 (150)	61 (135)
Power W.	170 (av.), 224 (pk.)	80 (av.), 250 (pk.)
	Film temp. control to 68 $\pm 5^{\circ}$F, 0.1 PSI, 50% rel. humidity	
Platform/Data Considerations		
Pointing Accuracy	1.0 degree	
Line of Sight Rate (max.)	IMC range 10 to 30 mR/sec, 5% accuracy	
Data Output	24 x 48 cm (9 x 18 in. film)	
Comments:	Use in conjunction with Panoramic Camera (No. 3) for mapping.	

(1) PAN-X B&W film, Type 3400.

INSTRUMENT SPECIFICATION No. 5

SENSOR: MULTISPECTRAL CAMERA SYSTEM (24 x 24 cm. film)		
General Description		
Function	a) Multispectral photography, wide coverage, high resolution b) B/W and color photography, wide coverage, high resolution	
Configuration, Major Elements	Six boresighted mapping cameras (Type RC-10 or equiv.) 460 mm (18 in.) f.l. lenses. Gimballed $\pm 28^{\circ}$ cross-track. Camera selection (2 or 6) and filter selection required. Image motion compensation.	
Developmental Status	Operational in aircraft. Development for space flight required.	
Performance Characteristics		
Wavelength Range / Spectral Resolution	1. 0.5 - 0.6μ B&W 2. 0.6 - 0.7μ B&W 3. 0.7 - 0.8μ B&W IR	4. 0.8 - 0.9μ B&W IR 5. 0.5 - 0.88μ, false color 6. 0.5 - 0.7μ, aerial color
Field of View	$28^{\circ} \times 28^{\circ}$, 185 x 185 Km (100 x 100 n. mi.) from 370 Km altitude	
Spatial Resolution	12.5 m/line-pair (66 ℓpm lens-film AWAR, TOC = 1.6/1)(1)	
Sensitivity	1 to 10 mSec shutter speed, continuously variable. f/4.5 to f/16 in half-stop increments.	
Physical Characteristics	Cameras and Cassettes (2)	Gimbals and Control
Size cm. (in.)	147 x 105 x 97 (58x41x38)	172 x 109 x 68 (68x43x27)
Weight Kg (lb.)	760 (1670) (6 cameras)	364 (800)
Power W	500/1500 (2/6 cameras)	500 (Av.), 1500 (Pk.)
	Film Temp. Control to 68 $\pm 5^{\circ}$F, 0.1 PSI, 50% Rel. Humidity	
Platform/Data Considerations		
Pointing Accuracy	1.0 degree	
Line of Sight Rate (max.)	IMC Range 10 to 30 mR/Sec., controlled to 5% accuracy	
Data Output	24 x 24 cm (9 x 9 in.) film	
Comments:		

(1) PAN-X B&W film, Type 3400. (2) Specifications for six cameras.

INSTRUMENT SPECIFICATION No. 6

SENSOR: HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film)		
General Description		
Function	High resolution multispectral photography of selected target areas.	
Configuration, Major Elements	Six boresighted and synchronized 70 mm film cameras, 1800 mm (72 in.) f.l. Catadioptric lenses. Two-axis gimballing $\pm 40^{\circ}$, slaved to tracking telescope. Interchangeable filters. Image motion compensation by rate gyro control.	
Developmental Status	Similar to Skylab S190.	
Performance Characteristics		
Wavelength Range / Spectral Resolution	1. $0.5-0.6\mu$, B&W 2. $0.6-0.7\mu$, B&W 3. $0.7-0.8\mu$, B&W IR	4. $0.8-0.9\mu$, B&W IR 5. 0.5-0.88 false color 6. 0.4-0.7 aerial color
Field of View	$1.75 \times 1.75^{\circ}$, 11.6 Km. (6.25 n. mi.) from 370 Km altitude.	
Spatial Resolution	6 m/line-pair (35 ℓ pm lens-film AWAR, TOC = 1.6/1)(1)	
Sensitivity	2.5 to 50 m. sec. shutter speed, f/6.3 to f/16 in half-stop increments.	
Physical Characteristics	**Cameras and Cassettes**	**Gimbals and Control**
Size cm. (in.)	90 x 100 x 72 (35x39x28)(2)	140 x 80 x 63 (55x32x25)
Weight Kg (lbs)	90.7 (200)	63.5 (140)
Power W	100 (av.) 300 (pk.)	60 (av.) 300 pk.)
Platform/Data Considerations		
Pointing Accuracy	0.2 degree	
Line of Sight Rate (max.)	IMC range 10 to 30 mR/sec, controlled to 5% accuracy	
Data Output	70 mm film	
Comments:	IMC provided by rate gyro control. Film temperature control to $68 \pm 5^{\circ}$F. 0.1 PSI pressure, 50% relative humidity.	

(1) Ektrachrome IR Aero film, Type 8493 (2) Specifications for six cameras

INSTRUMENT SPECIFICATION No. 7

SENSOR: MULTIRESOLUTION CAMERA SYSTEM (24 x 24 cm. film)		
General Description		
Function	False color photography of earth resources with three different values of spatial resolution.	
Configuration, Major Elements	Three boresighted mapping cameras (Type RC-10 or equiv.) 460, 920, 1840 mm (18, 36, 72 in.) f.l. lenses. Gimballed $\pm 28^{\circ}$ cross-track. Image motion compensation.	
Developmental Status	Operational in aircraft. Development for space flight required.	
Performance Characteristics		
Wavelength Range	0.50 - 0.88μ (Ektachrome Infrared Aero-False Color)	
Spectral Resolution	0.38μ	
Field of View	$28^{\circ}/14^{\circ}/7.5^{\circ}$, 185 x 185/92 x 92/46 x 46 Km from 370 Km alt.	
Spatial Resolution	25/12.5/6.2 m/line-pair (33 ℓpm AWAR T.O.C. = 1.6/1)	
Sensitivity	1 to 10 msec shutter speed, continuously variable f/4.5 to f16 in half-stop increments	
Physical Characteristics	**Cameras and Cassettes**	**Gimbals and Control**
Size cm. (in.)	148 x 105 x 43 (58 x 41 x 17)[1]	172 x 68 x 50 (68x40x20)
Weight Kg (Lb.)	380 (835) (3 cameras)	182 (400)
Power W	750 (3 cameras)	250 (Av.), 750 (Pk.)
Platform/Data Considerations		
Pointing Accuracy	0.5 deg.	
Line of Sight Rate (max.)	IMC Range 10 to 30 mR/sec; controlled to 5% accuracy	
Data Output	24 x 24 cm. (9 x 9 in.) film Film Temp. Control to 68 $\pm 5^{\circ}$F, 0.1 PSI, 50% relative humidity	
Comments:	Use Wild NF-2 Navigation Sight (or equivalent) (Instrument No. 32) in conjunction with this system. Catadioptric lens should be considered for 1840 mm f.l. lens	

(1) Specifications for three cameras

SENSOR: HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER

General Description	
Function	To obtain multispectral imagery of the terrain for use in agricultural, forestry, geological, and hydrological observations.
Configuration, Major Elements	Similar to EOS 7-band Thematic Mapper or Skylab 13-band Scanner. Reflective optic, image plane scanning, multiple spectral filters and detectors. Closed-cycle Vuilleumier Cooler for IR detectors. Electronic (signal processing) assembly.
Developmental Status	State-of-the-art technology. Development required.
Performance Characteristics	
Wavelength Range	0.4-1.0 μ (9 bands), 1-5 μ (5 bands), 8-13 μ (6 bands)
Spectral Resolution	(0.4-1.0 μ) .05 μ, (1-5 μ) 0.12 to 0.45 μ, (8-13 μ) 0.5 to 1.0 μ
Field of View	(0.4-1.0 μ) 87 μR, (1-5 μ) 87 μR, (8-13 μ) 173 μR
Spatial Resolution	(0.4-1.0 μ) 30 m, (1-5 μ) 30 m, (8-13 μ) 60 m
Sensitivity	(0.4-1.0 μ) $NE\Delta\rho = 1\%$, (1-5 μ) $NE\Delta\rho = 1\text{-}2.5\%$, (8-13 μ) $NE\Delta T = 1\text{-}2^{o}K$
No. Detectors/Band	(0.4-1.0 μ) 2, (1-5 μ) 2, (8-13 μ) 1

Physical Characteristics		Scanner	V-M Cooler	Electronic Asmb.	Gimbal Sys.
Size	cu. m. (ft^3)	0.51 (18)	0.05 (0.16)	0.034 (1.2)	0.42 (15)
Weight	Kg (lb)	100 (225)	3.7 (8)	34 (75)	63.5 (190)
Power	W	266	45	(incl. in scanner)	60 (av.) 300 (pk.)

Platform/Data Considerations	
Pointing Accuracy	0.5 degree
Line of Sight Rate (max.)	3 arc-min/sec (max.)
Data Output	200 MB/S PK (8-bit encoding, 33% duty cycle), all 20 bands. Data recording limitation may require use of only selected bands.
Comments:	Pointable $\pm 22^{o}$ cross-track (one-axis gimbals) Swath width = 62 Km (33 n. mi.), IFOV = 30 & 60 m (H = 370 Km) Conical scan, 7200 RPM, 33% scan efficiency.

INSTRUMENT SPECIFICATION No. 9

SENSOR: LONG WAVELENGTH INFRARED SPECTROMETER	
General Description	
Function	Geologic Surveys - Identification of types of rock, sand, sediments, and soils.
Configuration, Major Elements	Cassegrain Telescope (25 cm. dia.), 2-band spectrometer, radiometer, pointing mirror, roll gimbal, visual viewer and identification camera.
Developmental Status	Similar to Skylab S-191 with radiometric channel added.
Performance Characteristics	
Wavelength Range	Spectrometry (0.4-2.4μ, 6.2-15.5μ), radiometry (10.1-12.5μ)
Spectral Resolution	Spectrometry (0.1-0.5μ, 0.1-0.3μ), radiometry (2.4μ)
Field of View	1 m Rad, gimballed $+45^{\circ}$, -10° along track, $\pm 20^{\circ}$ cross track
Spatial Resolution	0.37 Km from orbital altitude of 370 Km
Sensitivity	(0.4-2.4μ) 1.2 to 8×10^{-5} w/cm^2-st, (6.2 - 15.5μ) 1.5 to 8×10^{-5} w/cm^2-st. Temperature 0.1 K$^{\circ}$
Physical Characteristics	
Size cm. (in.)	51 x 51 x 130 (20 x 20 x 51)
Weight Kg (lb.)	182 (402)
Power W	200 (av.)
Platform/Data Considerations	
Pointing Accuracy	0.3 degree (manual pointing by astronaut)
Line of Sight Rate (max.)	0.10 m R/sec
Data Output	Spectrometry 684 samples/sec x 10-bit encoding = 6.84 KB/S Spectral scan rate = 1/sec. Radiometry 10 S/S, 10-bit, 100 B/S
Comments:	Operates in target tracking mode.

INSTRUMENT SPECIFICATION No. 10A

SENSOR:	WIDE BAND SYNTHETIC APERTURE RADAR (WBSAR) (WIDE COVERAGE, LOW RESOLUTION MODE)
General Description	
Function	Radar mapping of ice fields by contrast with sea water scattering
Configuration, Major Elements	Antenna, transmitter, 2 receivers, 2 film recorders, power supply
Developmental Status	Development for space required
Performance Characteristics	
Wavelength Range	10 GHz
Spectral Resolution	50 MHz Bandwidth
Field of View	250 Km Swathwidth (from 370 Km altitude)
Spatial Resolution	100 m
Sensitivity	$\sigma_o > -20$ dB
Beam Depression Angle	34 deg., Beamwidth≈12 deg.
Physical Characteristics $m^3 (ft^3)$	T_X/R_X 0.1(3), Rec. 0.7(24), p.s. 0.06(2)
Size $m^3 (ft^3)$	Antenna 8.7 x 0.35 x 0.2 (28.3 x 1.15 x 0.5), 6.1 m^3 (22 ft^3)
Weight Kg (lb)	275 (600) total; ant. 70(150), T_X/R_X 70(150), rec. 90(200), power supply 45 (100)
Power W	1200
Platform/Data Considerations	
Pointing Accuracy	0.5 degree
Line of Sight Rate (max.)	1.5 mr/sec
Data Output	Data recorded on film
Comments:	Transmits single polarization. Receives dual polarization. Experiments O2, M6, H2.

INSTRUMENTATION SPECIFICATION No. 10B

SENSOR:	WIDE BAND SYNTHETIC APERTURE RADAR (WBSAR) (MEDIUM COVERAGE, HIGH RESOLUTION MODE)
General Description	
Function	Radar images of ocean surface backscattering for determination of pollution and wind patterns
Configuration, Major Elements	Antenna, transmitter, 2 receivers, 2 film recorders, power supply
Developmental Status	Development for space required
Performance Characteristics	
Wavelength Range	10 GHz
Spectral Resolution	50 MHz Bandwidth
Field of View	100 Km Swathwidth (from 370 Km altitude)
Spatial Resolution	30 meters at 200 n. mi. altitude
Sensitivity	$\sigma_o > -25$ dB/5 knot wind
Beam Depression Angle	60 deg., Beamwidth $\simeq$ 12 deg.
Physical Characteristics $m^3 (ft^3)$	T_X/R_X 0.1(3), rec. 0.7(24), p.s. 0.06 (2)
Size $m^3 (ft^3)$	Antenna 8.7 x 0.35 x 0.2 (28.3 x 1.15 x 0.5), 6.1 m^3 (22 ft^3)
Weight Kg (lb)	275(600) Total; Ant. 70(150), T_X/R_X 70(150), rec. 90(200) power supply 45(100)
Power W	2400
Platform/Data Considerations	
Pointing Accuracy	0.5 degree
Line of Sight Rate (max.)	0.6 mr/sec
Data Output	Data recorded on film
Comments:	Transmits single polarization. Receives dual polarization. Experiments O1, O5, H3.

SENSOR: MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (MEDIUM COVERAGE, LOW RESOLUTION MODE)	
General Description	
Function	Radar images of surface backscattering for determination of soil conditions and crops identification.
Configuration, Major Elements	3 antennas; 3 transmitters; 6 receivers; 6 film recorders, power supply.
Developmental Status	SR and T and development required
Performance Characteristics	
Wavelength Range	3, 5.5, and 10 GHz
Spectral Resolution	50 MHz Bandwidth
Field of View	120 Km Swathwidth (from 370 Km altitude)
Spatial Resolution	30 meters at 200 n. mi. altitude
Sensitivity	σ_o > -18 dB
Beam Depression Angle	60 deg., Beamwidth ≃ 14.5 deg.
Physical Characteristics $m^3 (ft^3)$	T_X/R_X 0.25(9), rec. 2.1(76), p.s. 0.1(3)
Size $m^3 (ft^3)$	Antenna 8.7 x 1.8 x 0.2 (28.3 x 6 x 0.5), 3.14 m^3 (111 ft^3)
Weight Kg (lb)	945 (2075) total; ant. 375 (825), T_X/R_X 210 (450), recorders 270 (600), p. s. 90 (200)
Power W	2300
Platform/Data Considerations	
Pointing Accuracy	0.5 degree
Line of Sight Rate (max.)	0.6 mr/sec
Data Output	Data recorded on film
Comments:	Transmits single polarization, receives dual polarization. Experiments G1, G2, G4, H4, H5

INSTRUMENT SPECIFICATION No. 11B

SENSOR: MULTI-FREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR) (NARROW COVERAGE, HIGH RESOLUTION MODE)	
General Description	
Function	Radar images of surface backscattering
Configuration, Major Elements	3 antennas; 3 transmitters; 6 receivers; 6 film recorders; power supply
Developmental Status	SRT and development required
Performance Characteristics	
Wavelength Range	3, 5.5, and 10 GHz
Spectral Resolution	50 MHz Bandwidth
Field of View Km	72 Km Swathwidth (from 370 Km altitude)
Spatial Resolution m (ft)	15 (50 ft)
Sensitivity	σ_o >-20 dB
Beam Depression Angle	60 deg., Beamwidth ≃ 8.6 deg.
Physical Characteristics $m^3 (ft^3)$	T_X/R_X 0.25 (9), rec. 2.1 (76), p.s. 0.1 (3)
Size $m^3 (ft^3)$	Antenna 8.7 x 3 x .20 (28.3 x 10 x 0.6 ft), 5.2 m^3 (185 ft^3)
Weight Kg (lb)	945 (2075) total; ant. 375(825), T_X/R_X 210 (450), recorders 270 (600), p.s. 90 (200)
Power W	2300
Platform/Data Considerations	
Pointing Accuracy	0.5 degree
Line of Sight Rate (max.)	0.3 mr/sec
Data Output	Data recorded on film
Comments:	Transmits single polarization, receives dual polarization. Experiments AFR1, AFR2, E1, OT2

INSTRUMENT SPECIFICATION No. 12

SENSOR: LASER ALTIMETER/SCATTEROMETER	
General Description	
Function	a) Profiling of mountainous terrain; b) Determination of wind and wave statistics on ocean surface; c) Determination of surface texture of ice and snow fields; d) Profiling of chlorophyll depth below ocean surface.
Configuration, Major Elements	Nd:YAG laser, Q-switched, optical frequency doubling. T/R switched mirror, reflective optics, PMT detector.
Developmental Status	Development required, chlorophyll profiling feasibility TBD.
Performance Characteristics	
Wavelength Range	0.53μ, 7.5 n sec. pulse width, 0.7 Joule/pulse, 3 pps
Spectral Resolution	NA
Field of View	Transmitter: 10 μRad., Receiver: 1 m Rad.
Spatial Resolution	4 m from orbital altitude of 370 Km (200 n. mi.)
Sensitivity	Range Accuracy: 25 cm.

Physical Characteristics		Optical Asmb.	Electronic Asmb.
Size	cm. (in.)	40 dia. x 80 (16 dia. x 32)	20 x 25 x 30 (8x10x12)
Weight	Kg (lb)	18 (40)	11.4 (25)
Power	W	150	30

Platform/Data Considerations	
Pointing Accuracy	0.1 degree
Line of Sight Rate (max.)	.05 deg/sec.
Data Output	150 BPS
Comments:	See TRW EOS Coastal Oceanographic Requirement Study pp 5-68 to 5-79 for design details.

INSTRUMENT SPECIFICATION No. 13

SENSOR: VISIBLE IMAGING SPECTROMETER		
General Description		
Function	Spectrometry and imaging of ocean surface color to identify organic matter, sedimentation, and pollution.	
Configuration, Major Elements	Imaging spectrometer; objective lens, collimating lens, diffraction grating, re-imaging lens, image dissector.	
Developmental Status	MOCS (Multichannel Ocean Color Sensor) developed by TRW Systems and flown under AAFE program.	
Performance Characteristics		
Wavelength Range	$.4 - .7\mu$	
Spectral Resolution	$.015\mu$ (20 spectral bands), 150 spatial elements	
Field of View	2.0 m R x 17.1° (one sensor), (2.0 m R x 51.3° (3 sensors)	
Spatial Resolution	0.74 Km (0.4 n. mi.) from orbital altitude of 370 Km (200 n. mi.)	
Sensitivity	$NE\Delta\rho = .001$	
Absolute Accuracy	10% absolute, 0.2% relative radiometry	
Physical Characteristics	**One Instrument**	**Three Instruments**
Size cm. (in.)	18 x 18 x 48 (7x7x19)	18 x 82 x 48 (7x32x19)
Weight Kg (lb)	23 (50)	69 (150)
Power W	25	75
Platform/Data Considerations	**One Instrument**	**Three Instruments**
Pointing Accuracy	1.0 degree	Same
Line of Sight Rate (max.)	.05 deg/sec	Same
Data Output	126 KB/S for 20 channels (12 bit encoding, 3.5 frames/sec)	378 KB/S for 20 channels Same
Comments:	One sensor will give swath width of 112 Km (60.4 n. mi.) Three sensors will give swath width of 398 Km (214 n. mi.)	

SENSOR: IR - MULTISPECTRAL MECHANICAL SCANNER

General Description	
Function	Thermal mapping of the sea surface. Effect of water vapor removed from data by using three IR spectral bands. Additional spectral bands to measure cloud cover.
Configuration, Major Elements	Conical scan, 17.6 cm dia. f/3.7 optics, HgCdTe detector for IR bands, cooled to 90°K by either active Velliumier closed cycle system or radiative cooler.
Development Status	Development required.
Performance Characteristics	
Wavelength Range	0.2 - 4.0μ (clouds-daytime), 3.6 - 4.1μ (clouds-night) 6.5 - 7.0μ (H_2O), 8.85 - 9.35 (H_2O), 10.5 - 11.5μ (IR window)
Field of View	Conical scan 30° from nadir. 120° active.
Spatial Resolution	IFOV = 2 x 2 m Rad. Ground Resolution = 0.74 x 0.85 Km (H = 370 Km)
Sensitivity	0.12 K° (10.5 - 11.5μ), 0.2 K° (8.55 - 9.35μ)
Physical Characteristics	
Size cm.	Conical configuration, 25 cm dia. at top, 80 cm dia. at bottom, 65 cm height. (add 15x15x20 cm for V-M cooler, if used)
Weight Kg (lbs)	43 (95) (add 3.7 (8) for V-M cooler, if used)
Power W	45 (add 45 W for V-M cooler, if used)
Platform/Data Considerations	
Pointing Accuracy	1.0 degree
Line of Sight Rate (max.)	2 m Rad/sec (at orbital altitude of 370 Km)
Data Output	7.45 MB/S (33% duty cycle), 2.5 MB/S with data stretching 5.0 MB/S if both forward and aft scan used (67% duty cycle)
Comments:	Spectral bands same as EOS Sea Surface Temperature Imaging Radiometer. (Configuration defined in TRW Global Oceanographic Requirement Study, Jan-1972, pp 7-43.)

INSTRUMENT SPECIFICATION No. 15

SENSOR: HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER

General Description	
Function	Spectrometry and imaging of ocean surface color to identify organic matter, sedimentation, and pollution.
Configuration, Major Elements	Imaging spectrometer; catadioptric (telephoto) objective lens, collimating lens, grating, re-imaging lens, image dissector.
Developmental Status	Similar to TRW Multichannel Ocean Color Sensor but uses smoothing (integrating) image dissector
Performance Characteristics	
Wavelength Range	0.4 - 0.7μ
Spectral Resolution	0.015μ (20 spectral bands)
Field of View	IFOV = 0.38 x 0.38 m R, FOV = 0.38 m R x 3.42 deg.
Spatial Resolution	0.38 m R (140 m from orbital altitude of 370 Km)
Sensitivity	10% absolute, 0.2% relative radiometry

Physical Characteristics		Sensor	Gimbals & Control[1]
Size	cm. (in.)	18 x 18 x 63 (7x7x25)	42 x 73 x 76 (17x29x30)
Weight	Kg (lb.)	13.6 (30)	22.8 (50)
Power	W	25	50 (av.) 200 (pk)

Platform/Data Considerations	
Pointing Accuracy	0.3 degree
Line of Sight Rate (max.)	0.02 m R/sec
Data Output	6 KB/S (12 bit encoding, 6 sec/frame) (20 spectral bands, 150 TVL/frame)
Comments:	Similar to Instrument No. 13 but uses telephoto rather than wide angle lens. Rate gyro stabilization required.

(1) Gimbal system used for both Instrument No. 15 and Instrument No. 16.

INSTRUMENT SPECIFICATION No. 16

SENSOR: HIGH RESOLUTION IR MULTISPECTRAL SCANNER

General Description	
Function	Thermal mapping of the sea surface, effect of water vapor removed from data by using three IR spectral bands. Additional spectral bands to measure cloud cover.
Configuration, Major Elements	Cassegrain optical system, 28 cm dia., f/8.0, two-axis plane mirror scanner (raster scan), HgCdTe detectors for IR bands, Velliumier closed-cycle or passive radiative cooler.
Development Status	Development for space flight required.
Performance Characteristics	
Wavelength Range	$0.2 - 0.4\mu$ (clouds-daytime), $3.6 - 4.1\mu$ (clouds-night) $6.5 - 7.0\mu$ (H_2O), $8.85 - 9.35\mu$ (H_2O), $10.5 - 11.5\mu$ (IR window)
Field of View	IFOV = 0.41 x 0.41 m Rad. Total FOV = 61 x 61 m Rad.
Spatial Resolution	150 m from orbital altitude of 370 Km (200 n. mi.)
Sensitivity	NEΔT = 0.09 K^o ($10.5 - 11.5\mu$), 0.15 K^o ($8.85 - 9.35\mu$) (150 x 150 Element Raster Scan) (Frame Scan Time = 4.7 sec.)

Physical Characteristics		Sensor	V-M Cooler	Gimbals & Control
Size	cm (in.)	20 x 20 x 60 (8x8x24)	Incl. in Sensor	See Instrument Spec. No. 15
Weight	Kg (lb)	16 (35)	3.7 (8)	
Power	W	35	45	

Platform/Data Considerations	
Pointing Accuracy	0.3 degree
Line of Sight Rate (max.)	1 m R/sec (H = 370 Km)
Data Output	240 KB/S (10 - Bit Encoding)
Comments:	Spectral bands identical to EOS Sea Surface Temperature Image Radiometer. Rate gyro stabilization required.

INSTRUMENT SPECIFICATION No. 17

SENSOR: GLITTER FRAMING CAMERA			
General Description			
Function	Primary: To obtain images of solar and lunar glitter pattern to deduce avg sea state and locate areas of reduced sea state Secondary: To obtain moderate resolution images of areas outside glitter pattern.		
Configuration, Major Elements	800 TV line camera (SEC Vidicon) ; f/2 optics with adjustable iris diaphragm f/2 to f/16; 2 axis gimballing or 2 axis pointing mirror.		
Developmental Status	State-of-the-art, development required.		
Performance Characteristics			
Wavelength Range	$0.58-0.7\mu$ - not critical but should be at red end of visible spectrum (solar), $0.4 - 0.7\mu$ (lunar)		
Spectral Resolution	$0.22, 0.30\mu$		
Field of View	$40^{\circ} \times 40^{\circ}$; Pointable $\pm 53^{\circ}$ on two axes from nadir.		
Spatial Resolution	0.85 m Rad., 315 m/TVL from 370 Km (200 n. mi.) altitude		
Sensitivity	64:1 dynamic range at any given exposure, additional 16:1 by varying exposure		
Absolute Accuracy	20 percent photometric		
Physical Characteristics	Camera	Electronics	Two-Axis Gimbals
Size cm. (in.)	10 x 16 40(4x6x16)	15 x 15 x 32(6x6x12.6)	28 x 28 x 38(11x11x15)
Weight Kg (lb)	3.6 (8)	3.6 (8)	5.5 (12)
Power W	10	10	20 (av.), 50 (pk)
Platform/Data Considerations			
Pointing Accuracy	1.0 degree		
Line of Sight Rate (max.)	0.35 deg./sec.		
Data Output	1.2 MB/s (6-bit) video, 10 sec/frame, 1 frame/30 sec		
Comments:	Brightness at center of solar glitter pattern varies from about 200 to 2500 $Lum/ft^2/ster$. Lunar glitter pattern varies from $3x10^{-4}$ to $4x10^{-3}$ $Lum/ft^2/ster$. 2 frames/min. give about 4 images of any point on surface.		

INSTRUMENT SPECIFICATION No. 18

SENSOR: STAR TRACKING TELESCOPE

General Description		
Function	Measurement of change in refraction angle of stars prior to occultation to determine atmospheric density.	
Configuration, Major Elements	Boresighted acquisition (Vidicon) star tracker and data (image dissector) star tracker mounted on 3-axis gimbal system. Rate gyro reference 0.01 deg./hr drift rate. Pulse-torque gyro control. CRT display, recording camera.	
Developmental Status	Stage of the art equipment. Development required.	
Performance Characteristics		
Wavelength Range	0.4 - 0.7 microns	
Spectral Resolution	0.4 - 0.7 microns	
Field of View	Acquisition star tracker $5^{\circ} \times 5^{\circ}$. Data star tracker 10 x 10 arc-min.	
Angular Accuracy	Instrument: 3 arc-sec. Data Star Tracker: 2 arc-sec. 1 arc-sec. resolution.	
Sensitivity	+6 visual magnitude.	
Physical Characteristics	Star Tracking Instrument	Electronic Unit
Size cm. (in.)	141 (55.5) x 107 (42.1) dia.	30 x 30 x 30 (11.8 x 11.8 x 11.8)
Weight Kg. (lb.)	41 (90)	16 (35)
Power W.	150 pk./80 av.	75 pk./50 av.
Platform/Data Considerations		
Pointing Accuracy	0.25 degree	
Line of Sight Rate	4 deg./min. orbital rate + 3 arc-min/sec. (max.) refraction rate	
Data Output	Time 26 bits, mode 14 bits, gyros (2) 28 bits, errors (2) 14 bits, AGC 7 bits. 10 samples/sec. 890 B/S total. 5 min. of data/sighting.	
Comments:	Pointing Angle Range: 90 deg. to 70 deg. from nadir (aft) in pitch. $\pm$30 deg. from orbital plane (aft) in azimuth. Similar to Apollo Applications "A" Experiment No. S-047, except instrument is configured for remote operation. Concurrent radiosonde measurements required.	

INSTRUMENT SPECIFICATION No. 19

SENSOR: UV UPPER ATMOSPHERIC SOUNDER (UVUAS)

General Description		
Function	Measure altitude profiles and secular changes in upper atmospheric constituents (O_3 from 30 to 55 km altitude and NO from 60 to 90 km altitude).	
Configuration, Major Elements	Telescope with MgF_2 optics, scanning Ebert Grating spectrometer, control and data handling electronics, 2-axis pointing mirror.	
Developmental Status	Under development for AAFE program (1970)	
Performance Characteristics		
Wavelength Range	2000 - 3000 Å	
Spectral Resolution	2 Å	
Field of View	1 - 3 degrees	
Spatial Resolution	17 - 50 km	
Sensitivity	15-bit data resolution	
Absolute Accuracy	Not specified	
Physical Characteristics	Sounder	Gimbal & Control
Size cm. (in.)	36 dia. x 66 (14.2 dia. x 26)	Integral with Sounder
Weight Kg(lb)	6.8 (15)	4.5 (10)
Power W.	15	10 pk., 5 av.
Platform/Data Considerations		
Pointing Accuracy	0.1 degree	
Line of Sight Rate (max.)	10 arc-min/sec	
Data Output	1.6 kbps	
Comments:	Dr. Charles Barth (University of Colorado) Principal Investigator. Considerable flexibility in operating modes and data rates.	

INSTRUMENT SPECIFICATION No. 20

SENSOR: VISIBLE RADIATION POLARIMETER (VRP)				
General Description				
Function	Measurement of the intensity and polarization of the sunlit atmosphere and terrain in several spectral bands.			
Configuration, Major Elements	Optical system, spectral filters, polarizing filters, silicon detectors.			
Developmental Status	State-of-the-art instrument. Development for space flight required.			
Performance Characteristics	O2 - Sea Ice Mapping	M1 - Noctilucent Clouds	M4 Air Pollution	H4 Snow & Ice
Wavelength Range (μ)	0.55	.46, .55, .67	.38, .44, .50, .58	0.55
Spectral Resolution (Å)	3000	300, 3000, 300	100	3000
Field of View (deg.)	3	0.3	3	0.3
Spatial Resolution* Km(n. mi)	18.5(10)	1.9 (1)	18.5 (10)	1.9 (1)
Sensitivity	TBD	TBD	TBD	TBD
Absolute Accuracy	5% Relative Photometric Accuracy			
Physical Characteristics	Polarimeter	Electronics	Gimbals & Control	
Size cm. (in.)	16 dia. x 30(6.3 dia. x 12)	30x30x30(12x12x12)	28x28x40(11x11x16)	
Weight Kg (lbs)	9 (20)	9 (20)	14 (32)	
Power W	20	20	75 W. pk/25 W. av.	
	Two-axis gimbals, ±75° from nadir			
Platform/Data Considerations				
Pointing Accuracy	0.5 degree			
Line of Sight Rate (max.)	0.1 deg/sec			
Data Output	500 bps			
Comments:	Technique under study at UCLA for measurement of particulate air pollution			

* From orbital altitude of 370 Km (200 n. mi.)

INSTRUMENT SPECIFICATION No. 21

SENSOR: AIR POLLUTION CORRELATION SPECTROMETER	
General Description	
Function	To determine global distribution of air pollutants, SO_2 (Industrial discharge) and NO_2 (automobile exhaust).
Configuration, Major Elements	Scanning mirror, optical system, dual correlation spectrometers.
Developmental Status	Proposed for Nimbus F.
Performance Characteristics	
Wavelength Range	2800 to 5000 Angstroms
Spectral Resolution	0.23 % of wavelength
Field of View	IFOV = 1° Scans $\pm 15^\circ$ Cross-track
Spatial Resolution	6.3 Km (3.4 n. mi.) from orbital altitude of 370 Km (200 n. mi.)
Sensitivity	Range: 20 to 2000 PPM/m for SO_2 and NO_2 Accuracy: 50% at 20 PPM/m; 10% at 2000 PPM/m
Physical Characteristics	Spectrometer
Size cm. (in.)	20 x 30 x 72 (7.9 x 11.8 x 28.4)
Weight Kg (lb)	13.6 (30)
Power W	15 W. Avg., 18 W. Peak, 10 W Standby
Platform/Data Considerations	
Pointing Accuracy	0.1 degree
Line of Sight Rate (max.)	2 m Rad/sec.
Data Output	7 B/S for 11 data channels, 12 housekeeping channels, and 6 monitoring channels.
Comments:	Configuration developed by Barringer Research Ltd. Ref: Space Applications Instrument Survey, NASA/ERC, 1970, pg 187.

INSTRUMENT SPECIFICATION No. 22

SENSOR: HIGH SPEED INTERFEROMETER (HSI)		
General Description		
Function	Measurement of total amount and vertical distribution of atmospheric pollutants: CO, CO_2, NO, $HC\ell$, O_3, NO_2, SO_2, NH_3 C_2H_2, C_2H_4, H_2CO.	
Configuration, Major Elements	Michelson Interferometer - Optics, Chopper, HeNe laser with PMT, interferometer, pyroelectric detectors (uncooled), reference blackbody source.	
Development Status	Breadboard model flown in blimp tests (AAFE & OMSF funding)	
Performance Characteristics		
Wavelength Range	1.2 to 8μ (downlooking); 200 cm^{-1} (pointing at earth limb and sun)	
Spectral Resolution	0.10 cm^{-1} (max.)	
Field of View (IFOV)	1.25° (earth-pointing), 0.25° (earth limb-pointing)	
Spatial Resolution	1.25°, 7.8 Km (4.2 n. mi.) at 370 Km altitude	
Sensitivity	5 to 500 PPB/Km (dependent upon species)	
Pointing Requirements	$\pm 45^o$ from nadir (two axes); point to sun at earth limb	
Physical Characteristics (1)	Interferometer	Gimbals & Control (2)
Size cm. (in.)	25 x 60 x 75 (10x24x30)	32 x 51 x 80 (12.6 x 20 x 31.5)
Weight Kg (lbs.)	23 (50)	(23) 50
Power W	150	130 pk/45 av.
Platform/Data Considerations		
Pointing Accuracy	0.25 deg.	
Line of Sight Rate (max.)	0.25 deg. stability during 3 min. or 15 sec. scan (target tracking)	
Data Output	14 bits + 1 parity bit/data point, 20 KB/S max. 65, 536 data points/spectrum, 0.983 MB total.	
Comments:	3 min./spectral scan (down-looking), 15 sec./scan (solar pointing). Slave to tracking telescope for target tracking. Two-axis gimbal and rate gyro stabilization required.	

(1) Preliminary Estimates
(2) Gimbal system used for both Instrument No. 22 and Instrument No. 23.

INSTRUMENT SPECIFICATION No. 23

SENSOR: CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)(1)	
General Description	
Function	1. Mapping of global concentration of atmospheric pollutants. 2. Measurement of vertical profiles of atmospheric pollutants by limb transmission experiment. 3. Measures CO, CO_2, SO_2, H_2O, NH_4, NO, N_2O, NO_2 concentr.
Configuration, Major Elements	Michelson type correlation interferometer.
Developmental Status	Initial funding under AAFE program. Further work funded by General Electric Company.
Performance Characteristics	
Wavelength Range	Either 1 to 3 or 3 to 5 micron spectral range (PbS or PbSe)
Spectral Resolution	Optical correlation of very fine spectral lines
Field of View	2 deg. (mapping mode),(2) 0.1 deg. (limb viewing-sun-oriented)
Spatial Resolution	12.6 Km (6.8 n. mi.) from 370 Km (200 n. mi.) altitude
Sensitivity	Depends upon pollutant being measured.
Physical Characteristics	Interferometer / Gimbals & Control
Size cm (in.)	26 x 30 x 74 (11 x 22 x 29) / See Instrument No. 22
Weight Kg (lbs)	21 (45)
Power W.	20 av. /35 pk.
Platform/Data Considerations	
Pointing Accuracy	0.5 deg. (earth-mapping), 0.05 deg. (solar pointing)
Line of Sight Rate (max.)	2 deg. /min.
Data Output	1.2 KB/S (serial), 6×10^6 bits/orbit (continuous data), 15-bit encoding.
Comments:	Detector cooled by Peltier cooler to 195 K°. In 3 - 5μ range, requires correlative data on atmospheric temp. profile.

Notes: 1. Current acronymn is CIMATS (Correlation Interferometric Measurement of Atmospheric Trace Species).
2. Views nadir only, cross-track scan not used.

INSTRUMENT SPECIFICATION No. 24

SENSOR: CLOUD PHYSICS RADIOMETER (CPR)					
General Description					
Function	To measure reflected solar radiation from clouds in five spectral bands to obtain data from which may be inferred: a) cloud top pressure level, b) density and phase of condensed water in clouds, c) a drop size parameter, d) optical and geometric thickness of clouds.				
Configuration, Major Elements	Rotating scan mirror, grating spectrometer, two PMT detectors, and three InAs detectors cooled to 120 K^o (or three uncooled PbS detectors).				
Developmental Status	Currently in preliminary design status.				
Performance Characteristics	Visible Window	O_2 Absorption Band	IR Window	CO_2 Absorption Band	IR Window
	(Ice vs Liquid Clouds)	(Cloud Thickness)	(Droplet Size Parameter)	(Density of Condensed Water)	(Cloud Top Pressure Level)
Wavelength Range	0.754	0.763	1.61	2.06	2.12 microns
Spectral Resolution	0.005	0.005	0.072	0.050	0.032 micron
Field of View	Transverse scan $\pm 51^o$ from nadir. IFOV 2.5 mRad.				
Spatial Resolution	(0.5 n. mi.) 0.92 km from altitude of 370 km (200 n. mi.)				
Sensitivity (NEΔρ)	Not Specified	Not Specified	0.014%	0.04%	0.06%
Absolute Accuracy	2% (0.1 percent relative for all channels)				
Physical Characteristics	Radiometer		V-M Cooler		
Size cm. (in.)	25.4 x 25.4 x 86 (10x10x33.8)		Included in Radiometer		
Weight Kg (lb)	32 (70)		3.6 (8)		
Power W.	40		45		
Platform/Data Considerations					
Pointing Accuracy	1 degree				
Line of Sight Rate (max.)	0.5 mrad/sec				
Data Output	0.64 Mbps (without buffer) /0.33 Mb/s (buffered), 10-bit encoding				
Comments:	Correlative meteorological data from aircraft is required.				

INSTRUMENT SPECIFICATION No. 25

SENSOR: REMOTE GAS FILTER CORRELATION ANALYZER (RGFCA)		
General Description		
Function	Global night and day meas. of tropospheric pollutants. Meas. of upper atmos. pollutant concentrations. Will meas. concentrations from 0.001 to 350 ppm of CO, CO_2, NO, NO_2, NH_3, and CH_4 in spectral regions from 2 to 20 microns.	
Configuration, Major Elements	Objective lens, collimating optics, selective gas filters, IR detectors, closed cycle cooler (77 K°).	
Developmental Status	Aircraft flight model under development by Science Applications, Inc. for AAFE Program	
Performance Characteristics		
Wavelength Range	2 to 20μ (CO - 4.6μ) (SO_2 - 7.4 and 8.7μ) (NO_2 - 10μ) NO - 5.4μ) (NH_3 - 10.5μ) are possibilities.	
Spectral Resolution	Fine resolution, dependent upon spectra of gases	
Field of View	5 deg. Scans laterally over an angle of 36.8 deg. at a rate of 1.6 deg/sec.	
Spatial Resolution	50 n. mi. from 600 n. mi. orbital altitude	
Sensitivity	0.001 to 350 ppm	
Absolute Accuracy	Better than 1 percent	
Physical Characteristics	Correlation Analyzer	Electronics
Size cm. (in.)	28 x 34 x 106 (11 x 13.4 x 41.7)	20 x 30 x 30 (7.9 x 11.8 x 11.8)
Weight Kg (lb)	14 (30)	9 (20)
Power	7 watts average, 10 watts peak	20
Platform/Data Considerations		
Pointing Accuracy	2 deg. in all axes (viewing nadir); 0.1 deg. (sun occultation tracking)	
Line of Sight Rate (max.)	1 mR/sec	
Data Output	<0.4 Kb/s	
Comments:	P.I. — C. B. Ludwig, Science Applications, Inc. Tropospheric measurements required pointing to nadir. Upper atmospheric measurements require pointing to sun during occultation of earth limb.	

INSTRUMENT SPECIFICATION No. 26

SENSOR: ADVANCED LIMB RADIANCE INVERSION RADIOMETER (ALRIR) (1)

General Description	
Function	Determination of the vertical distribution of temperature, ozone, water vapor, oxides of nitrogen, nitric acid, methane, and sulfate aerosols from the upper troposphere to the mesosphere.
Configuration, Major Elements	Radiometer, attitude reference unit, interface electronics unit. Scanning mirror, telescope, 10 HgCdTe detectors, Vuileumier cooler, electronics, blackbody calibration source.
Developmental Status	Currently in development under AAFE funding by Honeywell Aerospace Division for balloon flight tests.

Performance Characteristics (2)	NO_2	H_2O	CH_4	O_3	Sulf. Aer.	HNO_3	CO_2	N_2O
Wavelength Range (microns)	6.2	6.3	7.8	9.6	10.8	11.3	15	17.1
Spectral Resolution	N/S							
Field of View (mRad.)	1x2.5	1x2.5	1x2.5	0.5x2.5	1x2.5	0.5x0.5	0.25x2.5	1.0x2.5
Spatial Resolution (Km)	4x10	4x10	4x10	2x10	4x10	2x2	1x10	4x10
Sensitivity (w/m^2 - ster.) (Noise Eq. Radiance)	N/S	N/S	N/S	.0038	N/S	.001	.0045	.001

Physical Characteristics		Radiometer	V-M Cooler	Electronics
Size	cm. (in.)	37 x 49 x 116(14.6x18.5x62.5)	*	20 x 30 x 30 (8x12x12)
Weight	Kg. (lb.)	18 (40)	3.6 (8)	13.6 (30)
Power	W.	40 pk. /20 av.	45	40 pk. /30 av.

* incl. in radiometer

Platform/Data Considerations	
Pointing Accuracy	0.1 degree
Line of Sight Rate	LOS rate must be measured using rate gyro to accuracy of $\pm$0.0014 degrees during 4 sec. vertical scan (1 deg. /hr rate).
Data Output	4.0 Kb/sec.
Comments:	P.I. – Dr. John C. Gille, NCAR

(1) Current achronym is LACATE, Lower Atmosphere Composition and Temperature Experiment.

(2) Two additional channels are used for atmos. temp. measurement.

INSTRUMENT SPECIFICATION No. 27

SENSOR: TIROS N ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)

General Description	
Function	To obtain high resolution imagery of cloud cover and measurements of terrain and ocean temperature as supporting data for Remote Gas Filter Correlation Analyzer
Configuration, Major Elements	Scanning mirror, telescope, beam splitters, optical filters, relay lenses, silicon diodes or PMT's, HgCdTe detectors, passive radiative cooler (or closed-cycle V-M cooler).
Developmental Status	In development for TIROS-N

Performance Characteristics	Cloud Mapping	Terrain Mapping	Atmospheric Water Vapor Cirrus Clouds	Cloud Mapping Surface Temperature
Wavelength Range	$0.5 - 0.7\mu$	$0.75-1.0\mu$	$6.5-7.0\mu$	$10.5-12.5\mu$
Spectral Resolution	0.2μ	0.25μ	0.5μ	2.0μ
Field of View	Transverse line scan $+55^{\circ}$,(1) -70°(2) from nadir (rotary scan)			
Spatial Resolution	1 km (0.55 mr)	1 km (0.55 mr)	1 km (0.55 mr)	4 km(2.2 mr)
Sensitivity	NE$\Delta\rho$ 0.01	NE$\Delta\rho$ 0.01	1°K at 200°K	$.3^{\circ}$K at 300°K
Absolute Accuracy	Not specified			

Physical Characteristics	Radiometer	V-M Cooler
Size cm. (in.)	28 x 28 x 106 (11x11x41.7)	Included in Radiometer
Weight Kg (lb)	16 (35)	3.6 (8)
Power W	25	45

Platform/Data Considerations	
Pointing Accuracy	0.1 degree
Line of Sight Rate (max.)	0.4 mR/sec
Data Output	1.12 MB/S (8-bit encoding)

Comments:	Passive radiation cooling or closed-cycle Vuilleumier cooler required for Channels 3 and 4 to obtain detector temperature of 90°K.

(1) Toward the sun. (2) Away from sun.

SENSOR: TIROS-N OPERATIONAL VERTICAL SOUNDER (TOVS)

General Description	
Function	a. Atmos. temperature profiling (surface to 1 mb) b. Atmos. water vapor profiling (surface to tropopause) c. Determination of total amount of atmos. ozone (0.15 -0.60 cm)
Configuration, Major Elements	Optical systems (4 packages), cooled PbSe detector, TGS pyro-electric detectors, CO_2 cells, optical choppers, two-channel Dicke-type microwave radiometer
Developmental Status	Under study for use on TIROS-N

Performance Characteristics	OPA	OPB	OPC	OPD
Wavelength Range	3.70-4.54μ (6 bands)	9.7-29.41μ (10 bands)	14.97μ (1 band)	53.34 and 53.88 GHz
Spectral Resolution	25 - 35 cm^{-1}	15 - 25 cm^{-1}	1.3 cm^{-1}	220 MHz
Field of View	±40 degrees scan (cross-track)			
Spatial Resolution	1 degree	1 degree	10 degrees	10 degrees
Sensitivity	175 to 300 K deg. (temp); 0.0001 to 30 g/Kg(water vapor), 0.15 - 0.50 cm (ozone)			
Absolute Accuracy	±1 deg. K (temp.; 10 percent (water vapor); ±0.01 cm (ozone)			

Physical Characteristics	Total(1)	OPA	OPB	OPC	OPD	Elect.
Size cm.	--	20 D x 31	25x25x51	18 D x 25	10x15x31	20x20x33
Weight Kg (lb)	45 (99)	5.5 (12)	13.5 (30)	4.5 (10)	9 x (20)	10 (22)
Power W	73	10	18	5	15	15

Platform/Data Considerations	
Pointing Accuracy	0.5 deg.
Line of Sight Rate (max.)	0.05 deg/sec
Data Output	3 Kb/s

Comments:	
	P.I. –D. Wark, NOAA (1) Includes Peltier Cooler for OPA Detector, 2.3 Kg. (5 lb.), 10 W.

INSTRUMENT SPECIFICATION No. 29

SENSOR: PASSIVE MULTICHANNEL MICROWAVE RADIOMETER (PMMR)

General Description	
Function	Precipitation survey, establish sea surface roughness and wind, measure sea surface temperatures.
Configuration, Major Elements	Five conically scanned V and H polarization antennas, V and H receiver for each band, switch and scanning electronics and temperature references.
Development Status	Development required. Similar to scanning micro-wave radiometer being developed for Nimbus F
Performance Characteristics	
Wavelength Range	4.99, 10.69, 18, 21.5, 37 GHz
Spectral Resolution	200 MHz predetection bandwidth
Field of View	Antenna beamwidth (4.99 GHz) is 10.6 degrees, 5.3 degrees for the three mid-wavelengths, and 1.3 degrees for the 37 GHz band
Spatial Resolution	67, 33, 33, 33, 8.4 Km (from 370 Km orbital altitude)
Sensitivity	0.5 deg. K
Absolute Accuracy	1.5 deg. K

Physical Characteristics

Band (GHz)	4.99	10.69	18.00	21.50	37.00	Total
Size, Antenna m^2 (ft^2)	1.60(17.2)	1.30(14.0)	0.50(5.4)	0.35(3.8)	1.70(18.3)	5.45(58.5)
Weight Kg (lb) (1)	69(155)	48(107)	30(68)	25(55)	57(128)	230(513)
Power Watts (1)	90	80	50	40	95	355

(1) Specifications include receivers and power supply.

Platform/Data Considerations	
Pointing Accuracy	1.0 deg.
Line of Sight Rate (max.)	1.0 deg/sec
Data Output	~200 bps (10-bit encoding)

Comments: Use conical sector scanning. Half-cone angle 45 deg. from nadir. Sector scan angle ± 25 deg. about nadir. 325 km (177 n. mi) swath width from 370 km (200 n. mi.) altitude. 10 measurements/scan.

INSTRUMENT SPECIFICATION No. 30

SENSOR: MICROWAVE RADIOMETER/SCATTEROMETER

General Description	
Function	Measurement of sea surface roughness, altimetry.
Configuration, Major Elements	37 GHz Antenna, V&H Polarization, Trainable Antenna, Low Noise Receiver, Temp. References and Switching and Scanning Electronics.
Development Status	Similar to Skylab S193 with higher resolution. Antenna similar to Planar Array being developed for Nimbus F.
Performance Characteristics	
Wavelength Range	37 GHz
Spectral Resolution	300 MHz bandwidth
Field of View (IFOV)	2.6 m Rad., trainable (See Comments)
Spatial Resolution Km(n. mi.)	0.96 (0.52) from 370 Km (200 n. mi.) altitude
Sensitivity	1 Beaufort No. - Surface Roughness, 0.5 ^{o}K

Physical Characteristics		Antenna	Transmtr/Recvr.	Gimbal & Control
Size	cm. (in.)	300x300x15(118x118x6)	30x30x60(12x12x24)	254x30x30(100x12x12)
Weight	Kg (lb)	346 (760)	23 (50)	91 (200)
Power	W	217	50(T_X) /30 R_X	500 pk. /200 av.

Platform/Data Considerations	
Pointing Accuracy	1 degree
Line of Sight Rate (max.)	.06 mr/sec
Data Output	80 BPS
Comments:	Electronic scanning (one axis) $\pm$35 deg. normal to array. Array mechanically pointable $\pm$70 deg. in pitch.

INSTRUMENT SPECIFICATION No. 31

SENSOR: SFERICS RECEIVER

General Description			
Function	Detection of electromagnetic emission in the radio frequency range (sferics) from the atmosphere in areas of thunderstorm activity.		
Configuration, Major Elements	Three antennas, amplifiers, and receiver/signal processors.		
Developmental Status	State of the art. Development for space flight required.		
Performance Characteristics	HF	VHF	UHF
Wavelength Range	6 - 20 MHz (variable)	300 MHz	610 MHz
Spectral Resolution	1 KHz	2 MHz	2 MHz
Field of View	~90 deg.	50 - 60 deg.	50 - 60 deg.
Spatial Resolution	740 Km	425 Km	425 Km
Sensitivity	S/N >20 dB	S/N >20 dB	S/N >20 dB
Physical Characteristics	HF(1)	VHF(1)	UHF(1)
Size m^3 (ft^3)	0.017 (0.58)	0.19 (6.6)	0.04 (1.3)
Weight Kg (lb.)	10 (22)	12.8 (28)	9.5 (21)
Power W	20	20	20
	(1) Includes antennas, amplifiers, and receiver/signal processors		
Platform/Data Considerations			
Pointing Accuracy	5 degree	5 degree	5 degree
Line of Sight Rate (max.)	0.5 deg./sec.	0.5 deg./sec.	0.5 deg/sec.
Data Output	260 B/S	260 B/S	260 B/S
	(observation period = 20 to 30 min.)		
Comments:	Cavity-backed planar spiral antennas at 300 and 610 MHz. Half-wave dipole, 20 m. length, for 6 - 20 MHz band. All antennas fixed and pointed to the nadir.		

INSTRUMENT SPECIFICATION No. 32

SENSOR: WIDE ANGLE VIEWER/HYDROGEN ALPHA LINE VIEWER	
General Description	
Function	Visual observation of lightning flashes associated with electromagnetic emissions (sferics) from the atmosphere in areas of thunderstorm activity.
Configuration, Major Elements	Optical viewfinder, similar to Wild NF2 navigation sight, with removable narrow-band spectral filter and TV camera.
Developmental Status	Operational in aircraft. Development for space flight required.
Performance Characteristics	
Wavelength Range	(Daytime) 6563 Å, (Night time) 0.4 - 0.7μ
Spectral Resolution	(Daytime) 50 Å, (Night time) 0.3μ
Field of View	$110^{\circ}/55^{\circ}/28^{\circ}$ square, 0.5/1.0/2.0 x magnification 360° azimuth viewing capability. Gimballed, 0 to 60° from Nadir.

Physical Characteristics		Viewer	TV Camera
Size	Cm. (in.)	25.7 x 32.0 x 127.0 (10.1 x 12.6 x 50)	10 x 15 x 25 (4x6x10)
Weight	Kg. (lb.)	25 (55)	5.5 (12)
Power	W	10 (reticle illumination)	20
		Auxillary Equipment: CRT Display	

Platform/Data Considerations	
Pointing Accuracy	2 degrees
Line of Sight Rate (max.)	Not Critical
Data Output	N/A - Visual Observations
Comments:	Can be used as general-purpose wide-angle viewer for all experiments.

INSTRUMENT SPECIFICATION No. 33

SENSOR: DATA COLLECTION SYSTEM*					
General Description					
Function	a) Collection and relay of data from mobile and surface platforms in free-floating buoys & balloons and in fixed surface locations. b) Determination of platform location				
Configuration, Major Elements	Antenna, receiver, multiple-track tape recorder, and S-band transmitter				
Developmental Status	Phase A system study completed for application to TIROS-N satellite				
Performance Characteristics					
Wavelength Range	400 MHz uplink from platforms. S-band downlink from spacecraft.				
Spectral Resolution	Not applicable.				
Field of View	Receiver antenna gain = 2.5 2.5 dB; transmitter ant. gain = 1 to 2 dB				
Spatial Resolution	Not applicable				
Sensitivity	Receiver noise figure 3 dB, signal level -154.4 to -163.3 dBw				
Absolute Accuracy	Accuracy of sensor data = 1 percent				
Physical Characteristics	Receiver	Mx	Rcdr. Transport	Rcdr. Elect.	Transmitter
Size cm.	5x15x15	5x15x15	36 dia. x 15	13x15x25	15x20x33
Weight lb. (Kg)	1.4 (3)	1.4 (3)	6.4 (14)	2.3 (5)	2.7 (6)
Power W	2	2	←8→		80
Platform/Data Considerations					
Pointing Accuracy	Not critical				
Line of Sight Rate (max.)	Not critical				
Data Output	Data recording time 240 min at 30 kHz/each of 5 tracks. Data transfer time six minutes at 240 KHz.				
Comments:	Data storage capacity: Two orbits (1000 platforms per orbit). Direct recording on multiple-track tape recorder.				

* Configuration based upon Random Access Measurement System (RAMS) under study for TIROS -N Satellite.

APPENDIX B

EXPERIMENT INPUTS TO OTO AND PACER COMPUTER PROGRAMS

APPENDIX B

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EXPERIMENT INPUTS TO OTO AND PACER COMPUTER PROGRAMS

In order to select an orbit for a reference mission, each mission experiment must be considered in terms of:

- Target size and location
- Observation frequency
- Observation altitude
- Illumination constraints
- Optimization requirement

This Appendix defines each Level 1 experiment by specifying the requirements associated with the items mentioned above.

These requirements are used in the orbital optimization programs:

- (OTO) orbit track optimization
- (PACER) percent area coverage, earth resources

OTO is used if frequency of coverage is to be maximized and PACER is used if the percent of target area coverage is to be maximized.

DISCIPLINE: AGRICULTURE, FORESTRY, RANGELANDS

EXPERIMENT NO. AND TITLE: AFR1 - INTERNATIONAL AGRICULTURAL STATION MONITORING PROGRAM

TARGETS		
Number and Name	Latitude	Longitude
1. Manhattan, Kansas	$39^\circ 11'$N	$96^\circ 34'$W
2. Columbia, Mo.	$38^\circ 55'$N	$92^\circ 19'$W
3. Lincoln, Nebraska	$40^\circ 49'$N	$96^\circ 43'$W
4. Sioux Falls, S. Dak.	$43^\circ 33'$N	$96^\circ 43'$W
5. Bismark, N. Dak.	$46^\circ 48'$N	$100^\circ 46'$W
6. Riverside, Calif.	$33^\circ 59'$N	$119^\circ 21'$W
7. Salem, Oregon	$44^\circ 55'$N	$123^\circ 03'$W
8. Madison, Wis.	$43^\circ 05'$N	$89^\circ 23'$W
9. Ames, Iowa	$42^\circ 00'$N	$93^\circ 36'$W
10. Bowling Green, Ky.	$37^\circ 00'$N	$86^\circ 26'$W
11. Truth or Consequences, N. M.	$33^\circ 10'$N	107°-$20'$W
12. Champaign-Urbana, Ill.	$40^\circ 10'$N	88°-$15'$W
13. W. Lafayette, Ind.	$40^\circ 25'$N	$86^\circ 55'$W
14. Waltbury, Ct.	$41^\circ 30'$N	$73^\circ 00'$W
15. Baltimore, Md.	$39^\circ 05'$N	$76^\circ 40'$W
16. Fonyang, China	$32^\circ 53'$N	$115^\circ 48'$E
17. Tang fon, China	$32^\circ 54'$N	$117^\circ 22'$E
18. Chiang-Tu, China	$32^\circ 24'$N	$119^\circ 24'$E
19. Tung T-ai, China	$32^\circ 50'$N	$120^\circ 16'$E
20. Lini, China	$35^\circ 04'$N	$118^\circ 21'$E
21. Nan Cling, China	$26^\circ 40'$N	$118^\circ 05$E
22. Ube, Japan	$33^\circ 57'$	$131^\circ 18$E
23. Nemuro, Japan	$43^\circ 13'$N	$145^\circ 10'$E
24. Chittagong, Bangladesh	$22^\circ 26'$N	$90^\circ 51'$E

Observational Frequency(#Looks/#Days) —

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): ≥ 30

Time of Year: All Months*

Target Location —

F.O.V. (deg.): 9.5

Off-Nadir Pointing (deg.): ± 26.5

Optimization —

Mapping:

Target Pass: X

Comments —

16 targets required from list, as follows:

Any 6 from targets 1 - 15,
Any 3 from targets 16 - 23,
Any 2 from targets 24 - 28,
Any 1 from targets 29 - 31,
Any 4 from targets 32 - 42.

*March-September most desirable.

(continued)

DISCIPLINE: AGRICULTURE, FORESTRY, RANGELANDS

EXPERIMENT NO. AND TITLE: AFR1 - INTERNATIONAL AGRICULTURAL STATION MONITORING PROGRAM

TARGETS		
Number and Name	Latitude	Longitude
25. Dacca, Bangladesh	23°45'N	90°29'E
26. Ranchi, India	23°24'N	85°18'E
27. Kandy, Ceylon	7°18'N	80°42'E
28. Bassein, Burma	16°46'N	94°47'E
29. Damietta, UAR	31°22'N	31°50'E
30. Nicosia, Cyprus	35°10'N	33°22'E
31. Baghari, Algeria	35°50'N	2°48'E
32. Mersing, Malaysia	2°25'N	103°51'E
33. Goonoo Goonoo, Australia	31°25'S	150°44'E
34. Wagga-Wagga, Australia	35°10'S	147°30'E
35. Brewarrina, Australia	29°54'S	146°50'E
36. Thargomindah, Australia	27°58'S	143°57'E
37. Katherine, Australia	14°15'S	132°20'E
38. Esperance, Australia	33°45'S	122°07'E
39. Nornalup, Australia	35°00'S	117°00'E
40. Ingham, Australia	18°45'S	146°14'E
41. Burnie, Tasmania	41°15'S	146°05'E
42. U. of Sydney, Badgery-S. Creek Australia	34°05'S	150°35'E

DISCIPLINE: AGRICULTURE, FORESTRY, RANGELANDS

EXPERIMENT NO. AND TITLE: AFR2 - MULTISTAGE SAMPLING OF VEGETATION RESOURCES

TARGETS		
Number and Name	Latitude	Longitude
1. Bootheel of Missouri	36°-$36^{\circ}30'$N	$89^{\circ}30'$-$90^{\circ}30'$W
2. Central Valley of Calif.	$38^{\circ}30'$-$39^{\circ}30'$N	122°-123°W
3. Yellowstone Nat'l Park	44°-45°	110°-111°W
4. Lower Cape York Peninsula	15°-19°S	141°-145°E
5. Central Highlands, N. Guinea	6°-7°S	144°-146°E
6. Alajuela Prov., Costa Rica	10°-11°N	$83^{\circ}30'$-$84^{\circ}30'$W
7. Cordillera Central, P.R.	18°-$18^{\circ}20'$N	$66^{\circ}15'$-$67^{\circ}00'$W
8. Serra dos Carajas, Brazil	5°-7°S	51°-53°W
9. Lambarene, Gabon	0°-2°S	$9^{\circ}11^{\circ}$E
10. Kano, Nigeria	12°-13°N	8°-9°E
11. Between Teheran & Caspian Sea	$35^{\circ}30'$-$36^{\circ}30'$N	51°-52°E
12. Menaco, N. Celebes	$0^{\circ}30'$N -2°N	120°-125°E

<u>Observational Frequency(#Looks/#Days)</u> —

Desirable: 2/5

Acceptable: 1/5

<u>Altitude (n. mi.)</u> —

Desirable: 100-150

Acceptable: 150-300

<u>Illumination Constraints</u> —

Solar Elev. Angle (deg.): ≥30

Time of Year: All Seasons

<u>Target Location</u> —

F.O.V. (deg.): 9.5

Off-Nadir Pointing (deg.): ±26.5

<u>Optimization</u> —

Mapping:

Target Pass: X

<u>Comments</u> —

Any 5 targets required.

DISCIPLINE: AGRICULTURE, FORESTRY, RANGELANDS

EXPERIMENT NO. AND TITLE: AFR3 - WILDLIFE-ECOSYSTEM STUDIES

TARGETS		
Number and Name	Latitude	Longitude
1. Serengeti Plains	1°-$3^\circ 30'$S	33°-35°E
2. N. W. Oregon, near Bly	42°-43°N	121°-122°W
3. Alaska	65°-$66^\circ 50'$N	145°-150°W

Observational Frequency(# Looks/#Days) —

Desirable: 2/1

Acceptable: 1/2

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): ≥ 30; ≥ 20 Acceptable

Time of Year: Spring Desirable

Target Location —

F. O. V. (deg.): 9.5

Off-Nadir Pointing (deg.): ± 26.5

Optimization —

Mapping:

Target Pass:

Comments —

Any 2 targets required.

DISCIPLINE: AGRICULTURE, FORESTRY, RANGELANDS

EXPERIMENT NO. AND TITLE: AFR4 - WATER DAMAGE ASSESSMENT

TARGETS		
Number and Name	Latitude	Longitude
1. N. Carolina	36°-$36^{\circ}30'$N	81°-$82^{\circ}00'$W
2. Tennessee	35°-36°N	83°-85°W
3. Georgia	$34^{\circ}40'$-35°N	$83^{\circ}10'$-$84^{\circ}40'$W

Observational Frequency(#Looks/#Days) —

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): ≥ 30

Time of Year: March-April

Target Location —

F.O.V. (deg.): 7

Off-Nadir Pointing (deg.): ± 42

Optimization —

Mapping:

Target Pass: X

Comments —

Any 1 target required

DISCIPLINE: OCEANOGRAPHY

EXPERIMENT NO. AND TITLE: O1 - REGIONAL WATER POLLUTION

TARGETS		
Number and Name	Latitude	Longitude
1	33.5°-34.5°N	118°-121°W
2	37°-39°N	121°-123°W
3	45.2°N	124°W
4	42°-48°N	75°-92°W
5	29°-30.5°N	89°-90°W
6	40.5°-41.5°N	72°-74°W
7	37°-40°N	75°-77°W
8	29°-30°N	94°-95.5°W
9	41.5°N	70.6°
10	30.4°N	88.5°

Observational Frequency(#Looks/#Days) —

Desirable: 2-3/1

Acceptable: 1/2

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-250

Illumination Constraints —

Solar Elev. Angle (deg.): ≥30

Time of Year: April-May Desirable; Any Month Acceptable

Target Location —

F. O. V. (deg.): 51.3

Off-Nadir Pointing (deg.): ±25.7

Optimization —

Mapping:

Target Pass: X

Comments —

DISCIPLINE: OCEANOGRAPHY

EXPERIMENT NO. AND TITLE: O2 - SEA ICE MAPPING

TARGETS		
Number and Name	Latitude	Longitude
South Pole	80°-85.5°S	-
North Pole	80°-85°N	-

Observational Frequency(# Looks /# Days) —

Desirable: 1/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-250

Illumination Constraints —

Solar Elev. Angle (deg.): No Constraint

Time of Year: No Constraint

Target Location —

F.O.V. (deg.): 12

Off-Nadir Pointing (deg.): +50 to +62

Optimization —

Mapping:

Target Pass: X

Comments —

DISCIPLINE: OCEANOGRAPHY

EXPERIMENT NO. AND TITLE: O3 - PLANKTON PROFILING

TARGETS		
Number and Name	Latitude	Longitude
1	$5^{\circ}S-5^{\circ}N$	$80^{\circ}W-160^{\circ}W$
2	$12^{\circ}S-15^{\circ}S$	$75^{\circ}W-82^{\circ}W$
3	$2^{\circ}S-2^{\circ}N$	$40^{\circ}W-45^{\circ}W$
4	$10^{\circ}N-15^{\circ}N$	$65^{\circ}W-75^{\circ}W$
5	$10^{\circ}S-25^{\circ}S$	$160^{\circ}E-170^{\circ}E$
6	$12^{\circ}S-15^{\circ}S$	$127^{\circ}E-135^{\circ}E$
7	$0^{\circ}N-5^{\circ}N$	$0^{\circ}W-15^{\circ}W$
8	$10^{\circ}N-20^{\circ}N$	$12^{\circ}W-17^{\circ}W$

Observational Frequency(#Looks/#Days) —

Desirable: >3/1

Acceptable: 1/2

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-250

Illumination Constraints —

Solar Elev. Angle (deg.): $30^{\circ}-90^{\circ}$

Time of Year: Local Spring or Summer or Major Targets

Target Location —

F.O.V. (deg.): 0°

Off-Nadir Pointing (deg.): 0°

Optimization —

Mapping:

Target Pass: X

Comments —

DISCIPLINE: OCEANOGRAPHY

EXPERIMENT NO. AND TITLE: O4 - UPWELLING AREA MAPPING

TARGETS		
Number and Name	Latitude	Longitude
1	5°S-5°N	80°W-160°W
2	12°S-15°S	75°W-82°
3	2°S-2°N	40°W-45°W
4	10°N-15°N	65°W-75°W
5	10°S-25°S	160°E-170°E
6	12°S-15°S	127°E-135°E
7	0°N-5°N	0°W-15°W
8	10°N-20°N	12°W-17°W

Observational Frequency(#Looks/#Days) —

Desirable: >3/1

Acceptable: 1/1

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-250

Illumination Constraints —

Solar Elev. Angle (deg.): 30°-90°

Time of Year. January-March

Target Location —

F.O.V. (deg.): 51.3

Off-Nadir Pointing (deg.): $\pm 25.7^{\circ}$

Optimization —

Mapping:

Target Pass: X

Comments —

DISCIPLINE: OCEANOGRAPHY

EXPERIMENT NO. AND TITLE: O5 - OCEAN WIND AND WAVE MEASUREMENTS

TARGETS		
Number and Name	Latitude	Longitude
No Need to Specify Targets Until the Orbit is Selected.		

Observational Frequency(#Looks/#Days) —

Desirable: 2-3/1

Acceptable: 1/1

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-250

Illumination Constraints —

Solar Elev. Angle (deg.): 30-90

Time of Year: No Requirement

Target Location —

F.O.V. (deg.): 12

Off-Nadir Pointing (deg.): $+24^\circ$ to 36°

Optimization —

Mapping:

Target Pass: X

Comments —

DISCIPLINE: OCEANOGRAPHY

EXPERIMENT NO. AND TITLE: O6 - SUN GLITTER/MOON GLITTER MEASUREMENTS

TARGETS		
Number and Name	Latitude	Longitude
No Need to Specify Targets Until the Orbit is Selected.		

Observational Frequency(#Looks/#Days) —

Desirable: 2-3/1

Acceptable: 1/1

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-250

Illumination Constraints —

Solar Elev. Angle (deg.): --

Time of Year: All Seasons
Full Moon Conditions

Target Location —

F.O.V. (deg.): 28

Off-Nadir Pointing (deg.): ± 42

Optimization —

Mapping:

Target Pass: X

Comments —

The desirable inclination is equal to the sun's declination.

DISCIPLINE: ENVIRONMENTAL IMPACT

EXPERIMENT NO. AND TITLE: E1 - MONITORING EFFECTS OF CHANGING LAND USE PATTERNS ON WILDLIFE

TARGETS		
Number and Name	Latitude	Longitude
1. Serengeti Plains	1°-3°30'	33°-35
2. Cape York	15°-19°S	141°-145°E
3. Pampas	36°-38°S	64°-68°W

Observational Frequency(#Looks/#Days) —

Desirable: 1/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable:

Illumination Constraints —

Solar Elev. Angle (deg.): >30°

Time of Year: March-June; October-December

Target Location —

F.O.V. (deg.): 9.5°

Off-Nadir Pointing (deg.): ±26.5°

Optimization —

Mapping:

Target Pass: X

Comments —

DISCIPLINE: ENVIRONMENTAL IMPACT

EXPERIMENT NO. AND TITLE: E2 - LAKE EUTROPHICATION

TARGETS		
Number and Name	Latitude	Longitude
1. Lake Manitoba	50°30'N	98°30'W
2. Moosehead Lake	46°30'N	69°30'W
3. Lake Sebago	43°48'N	70°30'W
4. Grand Lake	49°N	57°30'W
5. Lake Champlain	44°30'N	73°12'W
6. Lake Winnipesaukee	43°30'N	71°24'W
7. Lake Ontario	43°30'N	77°W
8. Lake Simco	44°30'N	79°12'W
9. Mono Lake	38°N	119°W
10. Lake Winnebago	44°N	88°30'W
11. Lake Chippewa	45°54'N	91°12'W
12. Lake Moultrie	32°12'N	80°W
13. Lake Okeechobee	27°N	80°48'W
14. Douglas Lake	36°N	83°24'W
15. Lake Enid	34°06'N	89°54'W
16. White Lake	29°48'N	92°30'W
17. Lake of the Cherokees	36°30'N	94°48'W
18. Upper Red Lake	48°06'N	94°48'W
19. Leach Lake	47°06'N	94°30'W
20. Bear Lake	42°N	111°12'W
21. Utah Lake	40°12'N	111°48'W
22. Upper Klamath Lake	42°30'N	121°54'W
23. Yellowstone Lake	44°30'N	110°30'W
24. Flathead Lake	47°48'N	114°06'W
25. Lake Washington	47°30'N	122°30'W
26. Pyramid Lake	40°N	119°30'W
27. Lake Tahoe	39°N	120°W

Observational Frequency(#Looks/#Days) —

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): 45 Desirable; 30-60 Acceptable

Time of Year: Spring Desirable; Spring or Autumn Acceptable

Target Location —

F.O.V. (deg.): 51.3

Off-Nadir Pointing (deg.): ±25.7

Optimization —

Mapping:

Target Pass: X

Comments —

75 percent of targets required.

DISCIPLINE: ENVIRONMENTAL IMPACT

EXPERIMENT NO. AND TITLE: E3 - WATER USE PATTERN-IRRIGATION

TARGETS		
Number and Name	Latitude	Longitude
1. Euphrates River Area, Iraq	$34^{\circ}30'$-$35^{\circ}30'$N	39°-41°E
	$32^{\circ}30'$-$33^{\circ}30'$N	42°-44°E
	$30^{\circ}30'$-$31^{\circ}30'$N	46°-48°E

Observational Frequency(#Looks/#Days) —

Desirable: 1/1

Acceptable: 2/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): 40 Desirable
40-60 Accept.

Time of Year: All Seasons; at or near Equinoxes or Solstices Desired.

Target Location —

F. O. V. (deg.): 9.5

Off-Nadir Pointing (deg.): ± 26.5

Optimization —

Mapping:

Target Pass: X

Comments —

All targets required.

DISCIPLINE: HYDROLOGY

EXPERIMENT NO. AND TITLE: H1 - GROUND WATER DISCHARGE AND MAPPING

TARGETS			
Number and Name		Latitude	Longitude
1. Majave Desert	a.	34°30'N	117°W
	b.	34°42'N	118°W
2. Santa Lucia		14°N	61°W
3. Jamaica		18°N	77°W
4. Samoa		14°S	171°30'W
5. Papeete		17°42'S	149°12'W
6. Fiji		18°S	178°E

Observational Frequency(#Looks/#Days) —

Desirable: ≥2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): 45 Des. 35-55 Acc.

Time of Year: All Seasons; Spring most desirable.

Target Location —

F.O.V. (deg.): 9.5°

Off-Nadir Pointing (deg.): ±26.5°

Optimization —

Mapping:

Target Pass: X

Comments —

DISCIPLINE: HYDROLOGY

EXPERIMENT NO. AND TITLE: H2 - MAPPING GROUND STATE--FROZEN OR NOT

TARGETS		
Number and Name	Latitude	Longitude
Great Plains	A $1^\circ \times 1^\circ$ area within 45° - 50°N or A $1^\circ \times 1^\circ$ area within 40° - 45°N	A $1^\circ \times 1^\circ$ area within 110° - 110°W or A $1^\circ \times 1^\circ$ area within 90° - 100°W

Observational Frequency(# Looks/#Days) –

Desirable: 1/1

Acceptable: 3/5

Altitude (n. mi.) –

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints –

Solar Elev. Angle (deg.): 45 Des. 30-60 Acc.

Time of Year: Spring

Target Location –

F.O.V. (deg.): 12

Off-Nadir Pointing (deg.): +50 to +62

Optimization –

Mapping:

Target Pass: X

Comments –

Only one target desired.

DISCIPLINE: HYDROLOGY

EXPERIMENT NO. AND TITLE: H3 - SOIL MOISTURE MAPPING TECHNIQUE DEVELOPMENT

TARGETS		
Number and Name	Latitude	Longitude
Mississippi	32° - 33°N	92° - 93°W

Observational Frequency(#Looks/#Days) —

Desirable: 3/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): 45 Des. 30-60 Acc.

Time of Year: Spring

Target Location —

F.O.V. (deg.): 12

Off-Nadir Pointing (deg.): 24 - 36

Optimization —

Mapping:

Target Pass: T

Comments —

DISCIPLINE: HYDROLOGY

EXPERIMENT NO. AND TITLE: H4 - SNOW AND ICE MONITORING

TARGETS		
Number and Name	Latitude	Longitude
Polar Regions (N and S)	65° - 90°N; 65° - 90°S	All Longitudes

Observational Frequency(# Looks /#Days) —

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): >15 Des. 5-40 Acc.

Time of Year:

Most Desirable:
June-July (Northern Hemisphere)
Dec-Jan (Southern Hemisphere)
All Months Acceptable

Target Location —

F.O.V. (deg.): 14.5

Off-Nadir Pointing (deg.): 22.7 to 37.3

Optimization —

Mapping:

Target Pass: X

Comments —

DISCIPLINE: HYDROLOGY

EXPERIMENT NO. AND TITLE: H5 - INTERNATIONAL SEASONAL STANDING WATER SURVEY

TARGETS		
Number and Name	Latitude	Longitude
1. Mississippi Basin	35°N ± 1.5°	90°W ± 1.5°
2. High Plains	35°N ± 1.5°	102°W ± 1.5°
3. MRN, Great Plains	45°N ± 1.5°	100°W ± 1.5°
4. East Coast U.S.	35°N ± 1.5°	77°W ± 1.5°
5. Florida	27°N ± 1.5°	82°W ± 1.5°
6. Paraguay	25°S ± 1.5°	60°W ± 1.5°
7. NE Brazil	12°S ± 1.5°	40°W ± 1.5°
8. Australia, N	20°S ± 1.5°	141°E ± 1.5°
9. Australia, W	30°S ± 1.5°	120°E ± 1.5°
10. Chad, Africa	13°N ± 1.5°	15°E ± 1.5°
11. Timbuktu	16°N ± 1.5°	3°W ± 1.5°
12. Okovango	19°S ± 1.5°	20°E ± 1.5°
13. Bourdeaux, France	43°N ± 1.5°	0° ± 1.5°
14. Hamburg	53°N ± 1.5°	10°E ± 1.5°
15. Kiev	50.5°N ± 1.5°	31°E ± 1.5°
16. Iran	30°N ± 1.5°	53°E ± 1.5°

Observational Frequency(#Looks/#Days) —

Desirable: 1/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): 5 - 75

Time of Year: Spring Des.; Any Season Acceptable

Target Location —

F.O.V. (deg.): 14.5

Off-Nadir Pointing (deg.): +22.7 to +37.3

Optimization —

Mapping:

Target Pass: X

Comments —

75 percent of targets required.

DISCIPLINE: OTHERS

EXPERIMENT NO. AND TITLE: OT1 - ORTHOGRAPHIC MAPPING FOR DEVELOPING COUNTRIES; INTERNATIONAL OBLIQUE ILLUMINATION ORTHOPHOTO MAP SERIES

TARGETS

Number and Name	Latitude	Longitude
1. Mt. Rainier, Washington	$46^{\circ}30'$-47°N	$121^{\circ}30'$-122°W
2. Lawrence, Kansas	$38^{\circ}30'$-39°N	95°-$95^{\circ}30'$W
3. Harper's Ferry, W. Va.	$39^{\circ}39^{\circ}30'$N	$77^{\circ}30'$-78°W
4. Boulder, Colo.	40°-$40^{\circ}30'$N	105°-$105^{\circ}30'$N
5. N. Borneo	6°-7°N	117°-118°E
6. Zaire	0°-1°S	20°-21°E
7. Santarem, Brazil	2°-3°S	54°-55°W
8. Near Cayenne, Fr. Guiana	4°-5°N	52°-53°W

Observational Frequency (#Looks/#Days) —

Desirable: 4/5 (2 at each solar elev. angle)

Acceptable: 2/5 (2 at each solar elev. angle)

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elevation Angle (deg.):

Mt. Rainier, Wash.:	25-35 and $\geq$30
Lawrence, Kas.:	10-15 and $\geq$30
Harper's Ferry:	15-25 and $\geq$30
Boulder, Colo.:	25-35 and $\geq$30
N. Borneo:	10-20 and $\geq$30
Zaire:	10-20 and $\geq$30
Santarem, Brazil:	5-15 and $\geq$30
Near Cayene, Fr. Guiana	5-15 and $\geq$30

Time of Year: Summer; prefer June

Target Location —

F. O. V. (deg): 1.75
Off-Nadir Pointing: $\pm$41

Optimization —

Mapping:
Target Pass: X

Comments —

Low solar elevation angles for lower resolution visible sensors; higher solar elevation angles for high resolution sensors.

Prefer early A.M. for equatorial targets; late PM for mid-latitude targets.

Any two targets required.

DISCIPLINE: OTHERS

EXPERIMENT NO. AND TITLE: OT~~1~~2 - INTERNATIONAL DEVELOPMENT PROJECT PRE-FEASIBILITY ANALYSIS

TARGETS		
Number and Name	Latitude	Longitude
1. Petrolina, Brazil	8°-$9^{\circ}30'$S	40°-42°W
2. Surinam	$3^{\circ}50'$N-$4^{\circ}20'$N	34°-55°W
3. Awash Valley, Ethiopia	$10^{\circ}11^{\circ}$N	54°-55°W
4. Morocco	33°-34°N	3°-4°W
5. Zaire	10°-11°S	25°-26°E
6. Headwaters, Digoel River, W. Irian	5°-6°S	140°-141°E

Observational Frequency(#Looks/#Days) —

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): ≥ 30

Time of Year: All Seasons

Target Location —

F. O. V. (deg.): 8.6

Off-Nadir Pointing (deg.): +25.7 to 34.3

Optimization —

Mapping:

Target Pass: X

Comments —

Two targets required.

DISCIPLINE: OTHERS

EXPERIMENT NO. AND TITLE: OT3 - INTL. METROPOLITAN AREA BIENNIAL UPDATE

TARGETS		
Number and Name	Latitude	Longitude
1. Washington, DC	38°50'N	77°W
2. San Francisco	37°45'N	122°26°W
3. Boston	42°15'N	71°07'W
4. Seattle	47°36'N	122°20'W
5. Dallas	32°45'N	96°48'W
6. Kansas City, Mo.	39°05'N	94°35'W
7. Los Angeles	34°00'N	118°15'W
8. Chicago	41°49'N	87°37'W
9. St. Louis	38°39'N	90°15'W
10. Houston	29°46'N	95°21'W
11. New York	40°40'N	73°58'W
12. Pittsburgh	40°26'N	80°01'W
13. Denver	39°44'N	104°59'W
14. Sydney	33°55'S	151°17'E
15. Calcutta	22°32'N	88°22'E
16. Sao Paulo	23°34'S	46°38'W
17. Buenos Aires	34°20'S	58°30'W
18. Santiago	33°26'S	70°40'W
19. Mexico City	19°25'N	99°09'W
20. Montreal	45°30'N	73°35'W
21. Djakarta	6°17'S	106°45'E
22. Cape Town	33°48'S	18°28'E
23. Madrid	40°26'N	3°42'W
24. Teheran	35°45'N	51°30'E
25. Ankara	39°55'N	32°50'E
26. Algiers	36°51'N	2°56'E
27. London	51°30'N	0°07'W

Observational Frequency(#Looks/#Days) —

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): ≥30 *

Time of Year: **

Target Location —

F.O.V. (deg.): 9.5

Off-Nadir Pointing (deg.): ±26.5

Optimization —

Mapping:

Target Pass: X

Comments —

Any 10 targets required.

*Except for Washington, D.C. at 10°

**Order of Preference:
Spring or Autumn, Summer, Winter

DISCIPLINE: GEOLOGY

EXPERIMENT NO. AND TITLE: G1 - RAPID GEOLOGIC RECONNAISSANCE MAPPING

TARGETS		
Number and Name	Latitude	Longitude
1. Algeria	$20^\circ N \pm 1.5^\circ$ $30^\circ N \pm 1.5^\circ$	$10^\circ W \pm 1.5^\circ$ $0^\circ \pm 1.5^\circ$
2. Libya	$29^\circ N \pm 1.5^\circ$	$15^\circ E \pm 1.5^\circ$
3. UAR	$29^\circ N \pm 1.5^\circ$	$29^\circ E \pm 1.5^\circ$
4. Kalahari Desert	$23^\circ S \pm 1.5^\circ$	$22^\circ E \pm 1.5^\circ$
5. Great Sands Desert	$20^\circ S \pm 1.5^\circ$	$125^\circ E \pm 1.5^\circ$
6. Great Victoria Desert	$29^\circ S \pm 1.5^\circ$	$125^\circ E \pm 1.5^\circ$
7. Mojave Desert	$35^\circ N \pm 1.5^\circ$	$117^\circ W \pm 1.5^\circ$
8. W. Texas	$33.5^\circ N \pm 1.5^\circ$	$102^\circ W \pm 1.5^\circ$

Observational Frequency(#Looks/#Days) –

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) –

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints –

Solar Elev. Angle (deg.): 25-40

Time of Year: Any Season

Target Location –

F. O. V. (deg.): 14.5

Off-Nadir Pointing (deg.): +22.7 to 37.3

Optimization –

Mapping:

Target Pass:

Comments –

Required: 1 target from targets 7 and 8; then, at least 2 targets from targets 1 to 6.

DISCIPLINE: GEOLOGY

EXPERIMENT NO. AND TITLE: G2 - COASTAL GEOLOGY AND GEOMORPHIC PROCESSES

TARGETS		
Number and Name	**Latitude**	**Longitude**
1. S.E. U.S. Coast	$32^\circ N \pm 1^\circ$	$81^\circ W \pm 1^\circ$
	$34^\circ N \pm 1^\circ$	$78^\circ W \pm 1^\circ$
	$36^\circ N \pm 1^\circ$	$76^\circ W \pm 1^\circ$
2. N.E. U.S. Coast	$38^\circ N \pm 1^\circ$	$76^\circ W \pm 1^\circ$
	$40^\circ N \pm 1^\circ$	$74^\circ W \pm 1^\circ$
	$42^\circ N \pm 1^\circ$	$71^\circ W \pm 1^\circ$
	$44^\circ N \pm 1^\circ$	$69^\circ W \pm 1^\circ$
	$45^\circ N \pm 1^\circ$	$67^\circ W \pm 1^\circ$
3. W. Coast U.S.	$40^\circ N \pm 1^\circ$	$124^\circ W \pm 1^\circ$
	$37^\circ N \pm 1^\circ$	$122^\circ W \pm 1^\circ$
	$34^\circ N \pm 1^\circ$	$119^\circ W \pm 1^\circ$
	$32^\circ N \pm 1^\circ$	$117^\circ W \pm 1^\circ$
4. E. Coast, S. America	$40^\circ S \pm 1^\circ$	$64^\circ W \pm 1^\circ$
	$36^\circ S \pm 1^\circ$	$58^\circ W \pm 1^\circ$
	$32^\circ S \pm 1^\circ$	$52^\circ W \pm 1^\circ$
	$26^\circ S \pm 1^\circ$	$48^\circ W \pm 1^\circ$
	$24^\circ S \pm 1^\circ$	$46^\circ W \pm 1^\circ$
	$20^\circ S \pm 1^\circ$	$40^\circ W \pm 1^\circ$
	$14^\circ S \pm 1^\circ$	$39^\circ W \pm 1^\circ$

Observational Frequency(#Looks/#Days) —

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): ≥60 Des. ≥40 Acc.

Time of Year: All Seasons

Target Location —

F.O.V. (deg.): 14.5

Off-Nadir Pointing (deg.): +22.7 to 37.3

Optimization —

Mapping:

Target Pass: X

Comments —

4 targets required, with ≥50% of sub-targets required within each of 4 target area.

*Late Spring Most Desired

(continued)

DISCIPLINE: GEOLOGY

EXPERIMENT NO. AND TITLE: G2 - COASTAL GEOLOGY AND GEOMORPHIC PROCESSES

TARGETS		
Number and Name	Latitude	Longitude
5. W. Coast, Africa	34°S ±1°	19°E ±1°
	28°S ±1°	16°E ±1°
	24°S ±1°	15°E ±1°
	20°S ±1°	13°E ±1°
	16°S ±1°	12°E ±1°
	12°S ±1°	14°E ±1°
6. Sumatra Coast	5°N ±1°	95°E ±1°
	0° ±1°	100°E ±1°
	5°S ±1°	104°E ±1°
	0° ±1°	104°E ±1°
	3°N ±1°	100°E ±1°
7. E. Coast, Africa	32°S ±1°	29°E ±1°
	28°S ±1°	32°E ±1°
	24°S ±1°	35°E ±1°
	20°S ±1°	35°E ±1°
	18°S ±1°	37°E ±1°
	12°S ±1°	40°E ±1°
	4°S ±1°	40°E ±1°
	2°N ±1°	45°E ±1°
	6°N ±1°	49°E ±1°
	10°N ±1°	47°E ±1°

(continued)

TARGETS		
Number and Name	Latitude	Longitude
8. Red Sea	$22^\circ N \pm 1^\circ$	$37^\circ E \pm 1^\circ$
	$18^\circ N \pm 1^\circ$	$38^\circ E \pm 1^\circ$
	$14^\circ N \pm 1^\circ$	$42^\circ E \pm 1^\circ$
	$11^\circ N \pm 1^\circ$	$44^\circ E \pm 1^\circ$

DISCIPLINE: GEOLOGY

EXPERIMENT NO. AND TITLE: G4 - GEOLOGIC AND TOPOGRAPHIC MAPPING OF MOUNTAIN AREAS

TARGETS		
Number and Name	Latitude	Longitude
1. Ethiopia	8°-12°N	35°-41°E
	25°30'-28°30'N	86°30'-93°30'E
	29°30'-32°30'N	76°30'-83°30'E
	26°30'-29°30'N	81°30'-88°30'E
	34°30'-37°30'N	71°30'-78°30'E
	34°30'-37°30'N	66°30'-73°30'E
	26°30'-29°30'N	91°30'-98°30'E
2. New Guinea	2°30'-5°30'S	135°30'-138°30'E
	4°30'-7°30'S	143°30'-146°30'E
3. Turkey	37°-40°N	32°-38°E
	36°-39°N	36°-42°E
	37°-40°N	38°-44°E
4. Pyrenees Mountains	42°-43°N	1°W-3°E
5. Alps	42°30'-45°30'N	5°30'-8°30'E
	44°30'-47°30'N	6°30'-9°30'E
	45°30'-48°30'N	8°30'-11°30'E
	45°30'-48°30'N	11°30'-14°30'E

Observational Frequency(#Looks/#Days) —

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): 20-45 Des. ≥60 Acc.

Time of Year: All Seasons*

Target Location —

F.O.V. (deg.): 14.5

Off-Nadir Pointing (deg.): +22.7 to 37.3

Optimization —

Mapping:

Target Pass: X

Comments —

For each of at least 4 targets, at least 50% of specified areas must be ≥75% mapped.

*Desired near Solstices and Equinoxes

(continued)

TARGETS		
Number and Name	Latitude	Longitude
6. Andes	1°30'N-1°30'S	79°81°W
	3°30'-6°30'S	78°-80°W
	8°30'-11°30'S	76°-78°W
	13°30'-16°30'S	70°-72°W
	18°30'-21°30'S	68°-70°W
	28°30'-31°30'S	68°-70°W
	38°30'-41°30'S	70°-72°W
	48°30'-51°30'S	71°73°W
7. Rocky Mountains	58°30'-61°30'N	129°-131°W
	48°30'-51°30'N	114°-116°W
	38°30'-41°30'N	106°-108°W
	28°30'-31°30'N	104°-106°W
	23°30'-26°30'N	99°-101°W
8. Sierra Mountains	48°30'-51°30'N	119°30'-120°30'W
	38°30'-41°30'N	120°30'-121°30'W

DISCIPLINE: METEOROLOGY

EXPERIMENT NO. AND TITLE: M1 - NOCTILUCENT CLOUD PATROL

TARGETS		
Number and Name	Latitude	Longitude
Noctilucent Clouds at ~80 Km Altitude	60° - 80°N Desirable 45° - 80°N Acceptable	All

Observational Frequency(#Looks/#Days) –

Desirable: Whenever detected.*

Acceptable: Whenever detected.*

Altitude (n. mi.) –

Desirable: ≤ 300

Acceptable: ≤ 300

Illumination Constraints –

Solar Elev. Angle (deg.): Observations made in twilight zone.

Time of Year: Summer

Target Location –

F.O.V. (deg.): N/A

Off-Nadir Pointing (deg.): N/A

Optimization –

Mapping:

Target Pass: X

Comments –

*Targets of opportunity; detection required; astronaut scans twilight horizon.

DISCIPLINE: METEOROLOGY

EXPERIMENT NO. AND TITLE: M2 - STELLAR OCCULTATION

TARGETS		
Number and Name	Latitude	Longitude
Stars	All Desirable; 30^{o}N to 30^{o}S Acceptable	All

Observational Frequency(# Looks /#Days) –

Desirable: 4-5 stars/orbit; 20 orbits/5 days

Acceptable: 4-5 stars/orbit; 10 orbits/10 days

Altitude (n. mi.) –

Desirable: >100

Acceptable: 100-300

Illumination Constraints –

Solar Elev. Angle (deg.): Night-time measurements

Time of Year: No Preference

Target Location –

F. O. V. (deg.): N/A

Off-Nadir Pointing (deg.): N/A

Optimization –

Mapping:

Target Pass: X

Comments –

Stellar acquisition plus tracking time/ star ~6 minutes.

DISCIPLINE: METEOROLOGY

EXPERIMENT NO. AND TITLE: M3 - GLOBAL THUNDERSTORM AND LIGHTNING

TARGETS		
Number and Name	Latitude	Longitude
Thunderstorms, line squalls, clouds with convective activity	50°N to 50°S Desirable; 30°N to 30°S Acceptable	No Preference
Truth Sites	$36^{\circ}30'$N $28^{\circ}40'$N	117°W $80^{\circ}40'$W

Thunderstorms, etc. —
Observational Frequency(#Looks/#Days) —

See Comments: Sufficient Observational opportunities exist.

Truth Sites —
Observational Frequency(#Looks/#Days) —

Desirable: 1/2.5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: 100-200

Acceptable: 400

Illumination Constraints —

Solar Elev. Angle (deg.): No requirement

Time of Year: All seasons

Target Location —

F.O.V. (deg.): 28

Off-Nadir Pointing (deg.): ± 42

Optimization —

Mapping:

Target Pass: X

Comments —

Targets are mostly those of opportunity.

Both truth sites are required.

DISCIPLINE: METEOROLOGY

EXPERIMENT NO. AND TITLE: M4 - AIR POLLUTION MONITORING

TARGETS		
Number and Name	Latitude	Longitude
1. Los Angeles	33.7°-34.4°N	117°-119°W
2. San Francisco	37.2°-38.1°N	121.9-122.6°W
3. San Diego	32.5°-33.0°N	116.6°-117.3°W
4. Salt Lake City	40.5°-41.1°N	111.7°-112.2°W
5. Houston	29.3°-30.2°N	94.8°-95.7°W
6. St. Louis	38.4°-39.0°N	89.8°-90.5°W
7. Chicago	41.4°-42.2°N	97.1°-88.1°W
8. Atlanta	33.5°-34.0°N	84.2°-84.6°W
9. Birmingham	33.3°-33.8°N	86.5°-87.1°W
10. Boston	42.1°-42.6°N	70.7°-71.4°W
11. Pittsburgh	40.2°-40.8°N	79.6°-80.5°W
12. Miami	25.5°-26.1°N	80.0°-80.5°W
13. New York	40.4°-41.1°N	73.6°-74.4°W
14. Philadelphia	39.75°-40.25°N	74.8°-75.5°W
15. Washington/Baltimore	38.7°-39.4°N	76.4°-77.3°W

Observational Frequency(#Looks/#Days) —

Desirable: 2-3/1

Acceptable: 2/5

Altitude (n. mi.) —

Desirable: 100-150

Acceptable: 150-300

Illumination Constraints —

Solar Elev. Angle (deg.): ≥30

Time of Year: All Seasons*

Target Location —

F.O.V. (deg.): 5

Off-Nadir Pointing (deg.): ±21

Optimization —

Mapping:

Target Pass: X

Comments —

At least eight targets from target list are required.

*Priority: Autumn over Eastern U.S. and Summer over extreme Western U.S.

DISCIPLINE: METEOROLOGY

EXPERIMENT NO. AND TITLE: M5 - WEATHER MODIFICATION--TROPICAL STORMS

TARGETS		
Number and Name	Latitude	Longitude
Hurricanes	For the Gulf of Mexico, Caribbean, N. Atlantic (15° - 35°N), any 5°x5° square	60° - 95°W

Observational Frequency(# Looks /#Days) —

Desirable: 3/1 for 4 consecutive days.

Acceptable: 1/1 for 3 consecutive days.

Altitude (n. mi.) —

Desirable: ≤ 200

Acceptable: 200-400

Illumination Constraints —

Solar Elev. Angle (deg.): $\geq 25^{\circ}$ daytime observations

Time of Year: August-October

Target Location —

F.O.V. (deg.): 28

Off-Nadir Pointing (deg.): ± 42

Optimization —

Mapping:

Target Pass: X

Comments —

5° x 5° Lat/Long target area will move 5° to 10°/day in latitude and/or longitude.

DISCIPLINE: METEOROLOGY

EXPERIMENT NO. AND TITLE: M6 - ICE ON THE SOUTHERN OCEAN

TARGETS		
Number and Name	Latitude	Longitude
Pack Ice Over Antarctica	65°S, Sept-Oct 70°S, Jan. 77°S, Mar 71°S, Apr 67°S, July	All

Observational Frequency(#Looks/#Days) —

Desirable: 2/5

Acceptable: 1/5

Altitude (n. mi.) —

Desirable: ≤200

Acceptable: 200-400

Illumination Constraints —

Solar Elev. Angle (deg.): No Requirement

Time of Year: All Seasons.*

Target Location —

F.O.V. (deg.): 12

Off-Nadir Pointing (deg.): +50 to +62

Optimization —

Mapping:

Target Pass: X

Comments —

* Highest Priority Feb. and Sept.

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 14. IR MULTISPECTRAL SCANNER

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.150 m^3$ ($5 ft^3$)
- WEIGHT: 47 Kg (103 lb)
- POWER: 90 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	10 min.	Continuous over target	Time between targets	Over land masses
Power	90 W	90 W	90 W	0 W	0 W
Data	-	7.45 MB/S (33% duty cycle)	7.45 MB/S (33% duty cycle)	-	-
Film	-	-	-	-	-
Manpower	1/3	1	1/4	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

SENSOR: 15. HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.012\ m^3$ ($0.43\ ft^3$) Spectrom, $0.006 m^3$ (0. 3 ft^3) gimbals
- WEIGHT: 13.6 Kg (30 lb) Spectrom, 11.4 Kg (25 lb) Gimbals
- POWER: 25 W. Spectrom, 25 W(av), 100 W (pk) Gimbals

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	5 min.	18 sec. (3 frames) per target	Time between targets	Over land masses and during eclipse
Power	50 W	125 W (2-axis pointing)	125 W (2-axis pointing)	50 W	0 W
Data	-	6 KB/S	6 KB/S	-	-
Film	-	-	-	-	-
Manpower	1/2	1	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 16. HIGH RESOLUTION IR MULTISPECTRAL SCANNER

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.028 m^3 (1.0 ft^3) Scanner / 0.01 m^3 (0.35 ft^3) Gimbals
- WEIGHT: 25 Kg (53 lb) Scanner / 11.4 Kg (25 lb) Gimbals
- POWER: 90 W (Scanner) / 25 W (av) 100 W (pk) Gimbals

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	10 min.	15 sec (3 frames) per target	Time between targets	Over land masses
Power	115 W	190 W (2-axis pointing)	190 W (2-axis pointing)	115 W	0 W
Data	-	240 KB/S	240 KB/S	-	-
Film	-	-	-	-	-
Manpower	1/3	1/2	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

SENSOR: 17. GLITTER FRAMING CAMERA

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.008 m^3 (0.29 ft^3) Camera, 0.006 m^3 (0.20 ft^3) Gimbals
- WEIGHT: 7.3 Kg (16 lb) Camera, 5.5 Kg (12 lb) Gimbals
- POWER: 10 W Camera, 10 W (av), 30 W (pk) Gimbals

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	5 min.	10 sec./target	Time between targets	During eclipse
Power	10 W	30 W	30 W	10 W	0 W
Data	-	1.2 MB/S	1.2 MB/S	-	-
Film	-	-	-	-	-
Manpower	1/2	1	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 18. STAR TRACKING TELESCOPE

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.15 m^3 (3.8 ft^3)
- WEIGHT: 50 Kg (110 lbs)
- POWER: 60 W warm-up
  104 W pk
  65 W av

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	15 min.	2 min./acquisition 4 minutes/sighting	Between sightings	During daylight
Power	60 W	104 W	104 W	65 W	0 W
Data	-	890 B/S	890 B/S	-	-
Film	-	10 frames 35 mm film	4 frames 35 mm film	-	-
Manpower	1/3	1	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

APPENDIX C

SENSOR INPUTS TO AESOP

APPENDIX C

APPENDIX C

SENSOR INPUTS TO AESOP

The AESOP program requires three inputs: sensor data bank, mission/experiment priorities and an ephemeris tape. The former input is contained in this Appendix. It consists of:

- Resource requirements/sensor events matrices
- Sequencing matrices
- Operational priorities

The first part of the Appendix lists the resource requirements/sensor events matrices for each of the 33 sensors associated with the Level 1 experiments. The sensors are then grouped according to similarities in their sequencing requirements and operational priorities.

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: I. TRACKING TELESCOPE

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.375 m^3
- WEIGHT: 317 Kg (700 lb.)
- POWER: 94 W (av.), 125 W (pk.)

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	5 min. (warm-up)	10 min.	2 min/target	Time Between Targets	During Eclipse
Power	94 W	125 W	125 W	94 W	0
Data	0	0	0	0	0
Film	-	3 Frames 35 mm Film	1 Frame/60 sec. 35 mm Film	-	-
Manpower	1-1/2	1	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

SENSOR: 2. POINTABLE IDENTIFICATION CAMERA (70 MM)

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.03\ m^3$ Camera / $0.03\ m^3$ Gimbals
- WEIGHT: 23 Kg (50 lb) Camera / 23 Kg (50 lb) Gimbals
- POWER: 50 W (av.), 80 W (pk.) Camera / 30 W (av.), 100 W (pk.) Gimbals

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	5 min.	10 sec. /target	Time Between Targets	During Eclipse
Power	110 W	150 W (Pointing)	110 W	80 W	0
Data	0	Time, Cam. Temp, Lens Setting, Orbit No., Filter, Gimbal Angles	Same (On Mag. Tape)	0	0
Film	-	2 Frames 70 mm Film	2 Frames/25 sec. 70 mm Film	-	-
Manpower	1/3	1	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 3. PANORAMIC CAMERA

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.44\ m^3$
- WEIGHT: 129 Kg (283 lb) Space Envr. 91 Kg (200 lb) Shirtsleeve Envr.
- POWER: 234 W. (av.)

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	10 min.	Continuous over target	Time between targets	During eclipse
Power	234 W	234 W	234 W	160 W	0W
Data	-	Time, temp, f. p. slit setting, filter, orbit, gimbal angles	→ Same (Film code block)	-	-
Film		1 frame 11.5 x 128 cm film	1 frame/10 sec. 11.5 x 128 cm film	-	-
Manpower	1/3	1	1/4	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

SENSOR: 4. WIDE ANGLE FRAMING CAMERA (24 x 48 cm film)

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.27 m^3 Camera / 0.06 m^3 Gimbals
- WEIGHT: 68.5 Kg(150 lb) Camera / 61 Kg(135 lb) Gimbals
- POWER: 170 W (av) 224 W (pk) Camera / 80 W (av) 250 W (pk) Gimbals

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	10 min.	30 sec. /target	Time between targets	During eclipse
Power	250 W	420 W (pointing)	304 W	250 W	0
Data	-	Time, temp, f_{no}, filter, orbit, gimbal angles	→ Same (film code block)	-	-
Film	-	1 Frame 24 x 48 cm film	1 Frame 24 x 48 cm film	-	-
Manpower	1/3	1/2	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 5. MULTISPECTRAL CAMERA SYSTEM (24 x 24 cm. Film)

1) PHYSICAL REQUIREMENTS:

- SIZE: 2.0 m^3 Cameras / 0.41 m^3 Gimbals
- WEIGHT: 760 Kg (1670 lb) Cameras / 364 Kg (800 lb) Gimbals
- POWER: 500 W. 2 Cameras / 1500 W. 6 Cameras / 500 W (av.) 1500 W. (pk.) Gimbals

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	10 min.	30 sec/target	Time Between Targets	During Eclipse
Power	1 KW (2 Cam.) 2 KW (6 Cam.)	2 KW (2 Cam.) 3 KW (6 Cam.) (Pointing)	1 KW (2 Cam.) 2 KW (6 Cam.)	1 KW (2 Cam.) 2 KW (6 Cam.)	0
Data	--	Time, Cone Temp., Lens Setting, Filter Type, Orbit Gimbal Angles	→ Same (Film Code Block)	--	--
Film	--	2 or 6 Frames 24 x 24 cm film	2 or 6 frames 24 x 24 cm film	--	--
Manpower	1/3	1/2	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 6. HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film)

1) **PHYSICAL REQUIREMENTS:**

- SIZE: $0.12\ m^3$ Cameras; $0.09\ m^3$ Gimbals
- WEIGHT: 91 Kg (200 lb) Cameras; 64 Kg (140 lb) Gimbals
- POWER: 100 W (av) 300 W (pk) Camera; 60 W (av) 300 W (pk) Gimbals

2) **REQUIREMENTS:**

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	5 min.	30 sec/target	Time between targets	During eclipse
Power	160 W	600 W (tracking mode)	600W (tracking mode)	160 W	0
Data	-	Time, temp., f_{no}, filter, orbit, gimbal angles	→ Same (on mag tape)	-	-
Film	-	Six 70 mm frames	Six 70 mm frames per target	-	-
Manpower	1/3	1	1	0	0
Special					

3) **CONFLICTS WITH OTHER SENSORS:**

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 7. MULTIRESOLUTION CAMERA SYSTEM (24 x 24 cm film)

1) PHYSICAL REQUIREMENTS:

- SIZE: $1.0\ m^3$ Cameras / $0.21\ m^3$ Gimbals
- WEIGHT: 380 Kg (835 lb) Cameras / 182 Kg (400 lb) Gimbals
- POWER: 750 W Cameras / 250 W (av) 750 W (pk) Gimbals

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	10 min.	30 sec/target	Time between targets	During eclipse
Power	1 KW	1.5 KW (pointing)	1 KW	0	0
Data	-	Time, temp, f_{no}, filter, orbit, gimbal angles	→ Same (film code block)	-	-
Film	-	3 frames 24 x 24 cm film	3 frames 24 x 24 cm film	-	-
Manpower	1/3	1/2	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

SENSOR: 8. HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.59\ m^3$ Scanner
$0.09\ m^3$ Gimbals
- WEIGHT: 138 Kg (338 lb) Scanner
64 Kg (190 lb) Gimbals
- POWER: 311 W. Scanner
60 W (av) 300 W (pk) Gimbals

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	10 min.	Continuous over targets	Time between targets	Over ocean
Power	371 W	611W (pointing)	371 W	311 W	0
Data	-	200 MB/S (2) 33% duty cycle	200 MB/S 33% duty cycle (2)	-	-
Film	-	-	-	-	-
Manpower	1/3	1	1/4	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

(1) Annotation: Time, instrument temp., gimbal angles, orbit (on mag. tape)

(2) Using 20 spectral bands. Data rate can be reduced by use of only selected spectral bands.

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 9. LONG WAVELENGTH INFRARED SPECTROMETER

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.31 m^3
- WEIGHT: 182 Kg (402 lb)
- POWER: 200 W (av)

2) REQUIREMENTS:

Requirement	EVENTS: Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	15 min. (warm-up)	10 min.	20 sec./target	Time between targets	Over ocean
Power	200 W	200 W	200 W	100 W	0W
Data	-	6.94 KB/s + annotation(1)	6.94 KB/s + annotation(1)	-	-
Film	-	16 mm film	16 mm film	-	-
Manpower	1/3	1	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

(1) Annotation: Time, instrument temp., gimbal angles, orbit (on mag. tape).

SENSOR: 10A WIDEBAND SYNTHETIC APERTURE RADAR (WIDE COVERAGE, LOW RESOLUTION MODE)

1) PHYSICAL REQUIREMENTS:

- SIZE: 1.67 m^3 (60 ft^3)
- WEIGHT: 320 Kg (700 lbs)
- POWER: 1.08 KW

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	10 min.	Continuous over target area	Time between targets	At completion of experiment
Power	1.1 KW	1.1 KW	1.1 KW	0.2 KW	0W
Data	-	Housekeeping data on mag. tape	→ Same	-	-
Film	-	70 mm film	70 mm film	-	-
Manpower	1/2	1/2	1/4	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS: Cannot operate when passive RF equipment is being used (instruments 32, 33, 34).

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 10B WIDEBAND SYNTHETIC APERTURE RADAR (MEDIUM COVERAGE, HIGH RESOLUTION MODE)

1) PHYSICAL REQUIREMENTS:

- SIZE: 1.67 m^3 (60 ft^3)
- WEIGHT: 320 Kg (700 lb)
- POWER: 2.2 KW

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	10 min.	Continuous over target	Time between targets	At completion of experiment
Power	2.2 KW	2.2 KW	2.2 KW	0.2 KW	0 W
Data	-	Housekeeping data on mag. tape	→ Same	-	-
Film	-	70 mm film	70 mm film	-	-
Manpower	1/2	1/2	1/4	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS: Cannot operate when passive RF equipment is being used (Instruments 32, 33, 34).

SENSOR: 11A. MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR

1) PHYSICAL REQUIREMENTS: (MEDIUM COVERAGE, LOW RESOLUTION MODE)

- SIZE: $8.6\ m^3$ ($288\ ft^3$)
- WEIGHT: 990 Kg (2075 lb)
- POWER: 2 KW

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (Warm-up)	10 min.	Continuous over target	Time between targets	At completion of experiment
Power	2 KW	2 KW	2 KW	0.2 KW	0 KW
Data	-	Housekeeping data on mag. tape	Same	-	-
Film	-	70 mm film	70 mm film	-	-
Manpower	1/2	1/2	1/4	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS: Cannot operate when passive RF equipment is being used (instruments 32, 33, and 34).

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 11B. MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR

1) **PHYSICAL REQUIREMENTS:** (NARROW COVERAGE, HIGH RESOLUTION MODE)

- SIZE: 8.6 m^3 (288 ft^3)
- WEIGHT: 990 Kg (2075 lb)
- POWER: 2 KW

2) **REQUIREMENTS:**

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	10 min.	Continuous over target	Time between targets	At completion of experiment
Power	2 KW	2 KW	2 KW	0.2 KW	0 KW
Data	-	Housekeeping data on mag. tape	→ Same	-	-
Film	-	70 mm film	70 mm film	-	-
Manpower	1/2	1/2	1/4	0	0
Special					

3) **CONFLICTS WITH OTHER SENSORS:** Cannot operate when passive RF equipment is being used (instruments 32, 33, and 34).

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 12. LASER ALTIMETER/SCATTEROMETER

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.05\ m^3$
- WEIGHT: 18 Kg(40 lb)
- POWER: 150 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	10 min.	Continuous over target	Time between targets	At completion of experiment
Power	150 W	150 W	150 W	50 W	0 W
Data	0 B/S	150 B/S	150 B/S	0 B/S	0 B/S
Film	-	-	-	-	-
Manpower	1/2	1/2	0	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 13. VISIBLE IMAGING SPECTROMETER

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.084\ m^3$ ($3\ ft^3$) (3 instruments)
- WEIGHT: 69 Kg (150 lb) (3 instruments)
- POWER: 75 W (3 instruments)

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	5 min.	Continuous over target	Time between targets	During eclipse and over land masses
Power	75 W	75 W	75 W	0W	0W
Data	-	378 KB/S (3 instruments)	378 KB/S (3 instruments)	-	-
Film	-	-	-	-	-
Manpower	1/2	1	0	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

SENSOR: 19. UV UPPER ATMOSPHERIC SOUNDER (UVUAS)

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.01\ m^3$ ($0.35\ ft^3$)
- WEIGHT: 6.8 Kg (15 lb)
- POWER: 15 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	15 min.	5 min. / sighting	Between sightings and during eclipse	At end of mission
Power	10 W	15 W	15 W	10 W	0 W
Data	-	1.6 KB/S	1.6 KB/S	-	-
Film	-	-	-	-	-
Manpower	1/2	1	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 20. VISIBLE RADIATION POLARIMETER (VRP)

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.06\ m^3$ ($2.0\ ft^3$)
- WEIGHT: 18 Kg (40 lb)
- POWER: 20 W (av)
  45 W (pk)
  12 W (standby)

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	10 min.	2 min./sighting	Between sightings and during eclipse	At end of mission
Power	12 W	45 W	45 W	12 W	
Data	-	500 B/S	500 B/S	-	-
Film	-	-	-	-	-
Manpower	1/2	1	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

SENSOR: 21. AIR POLLUTION CORRELATION SPECTROMETER

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.028\ m^3$ ($1.0\ ft^3$)
- WEIGHT: 13.6 Kg (30 lb)
- POWER: 15 W (av.)
  18 W (pk.)
  10 W (standby)

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	Continuous over target area	Between sightings and during eclipse	At end of mission
Power	10 W	18 W	18 W	10 W	
Data	---	7 B/S	7 B/S	---	---
Film	---	---	---	---	---
Manpower	1/2	1	0	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 22. HIGH SPEED INTERFEROMETER (HSI)

1) **PHYSICAL REQUIREMENTS:**

- SIZE: $0.08\ m^3$ ($3.0\ ft^3$) Sensor
  $0.04\ m^3$ ($1.5\ ft^3$) Gimbals
- WEIGHT: 46 Kg (100 lb) Sensor
  23 Kg (50 lb) Gimbals
- POWER: 150 W Sensor
  100 W (pk), 30 W (av) Gimbals

2) **REQUIREMENTS:**

Requirement	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
	EVENTS				
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	15 sec/target	Between sightings and during eclipse	At end of mission
Power	180 W	250 W (w-axis pointing)	250 W (2-axis pointing)	30 W	0 W
Data	---	20 KB/S	20 KB/S	---	---
Film	---	---	---	---	---
Manpower	1/2	1	1	0	0
Special					

3) **CONFLICTS WITH OTHER SENSORS:**

SENSOR: 23. CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.04 m^3 (1.21 ft^3)
- WEIGHT: 20.5 Kg (45 lb)
- POWER: 20 W (av.)
35 W (pk.)
10 W (standby)

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	Continuous (Nadir - viewing)	Between sightings and during eclipse	At end of mission
Power	35 W	35 W	20 W	10 W	
Data	---		1.2 KB/S	---	---
Film	---	---	---	---	---
Manpower	1/2	1	0	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 24. CLOUD PHYSICS RADIOMETER (CPR)

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.043 m^3 (1.5 ft^3)
- WEIGHT: 32 Kg (70 lb)
- POWER: 40 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	Continuous over target area	Between sightings and during eclipse	At end of mission
Power	40 W	40 W	40 W	40 W	0 W
Data	---	0.64 MB/S	0.64 MB/S	---	---
Film	---	---	---	---	---
Manpower	1/2	1	0	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

SENSOR: 25. REMOTE GAS FILTER CORRELATION ANALYZER (RGFCA)

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.012 m^3 (0.42 ft^3)
- WEIGHT: 14 Kg (30 lb)
- POWER: 7 W (av.) / 10 W (pk)

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	Continuous over target area	Between sightings	At conclusion of experiment
Power	7 W	10 W	10 W	7 W	0 W
Data	---	3.6 KB/S	3.6 KB/S	---	---
Film	---	---	---	---	---
Manpower	1/2	1	0	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 26. ADVANCED LIMB RADIANCE INVERSION RADIOMETER (ALRIR)

1) **PHYSICAL REQUIREMENTS:**

- SIZE: $0.034\ m^3$
- WEIGHT: 16.4 Kg (36 lb)
- POWER: 81 W

2) **REQUIREMENTS:**

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	5 min/sighting (horizon)	Between sightings and during eclipse	At end of mission
Power	81 W	81 W	81 W	20 W	0 W
Data	---	3.6 KB/S	3.6 KB/S	---	---
Film	---	---	---	---	---
Manpower	1/2	1	0	0	0
Special					

3) **CONFLICTS WITH OTHER SENSORS:**

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 27. TIROS-N ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.049 m^3$ ($1.8 ft^3$)
- WEIGHT: 20 Kg (43 lb)
- POWER: 70 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	Continuous over target area	Between sightings	At conclusion of experiment
Power	70 W	70 W	70 W	30 W	0 W
Data	---	1.12 KB/S	1.12 KB/S	---	---
Film	---	---	---	---	---
Manpower	1/2	1	0	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 28. TIROS-N OPERATIONAL VERTICAL SOUNDER (TOVS)

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.041\ m^3$ ($1.46\ ft^3$) • WEIGHT: 47 Kg (101 lb) • POWER: 73 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	Continuous over target area	Between sightings	At conclusion of experiment
Power	73 W	73 W	73 W	25 W	0 W
Data	---	3 KB/S	3 KB/S	---	---
Film	---	---	---	---	---
Manpower	1/2	1	0	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 29. PASSIVE MULTICHANNEL MICROWAVE RADIOMETER (PMMR)

1) PHYSICAL REQUIREMENTS:

- SIZE: $5.45\ m^3$ ($58.5\ ft^3$) • WEIGHT: 230 Kg (513 lb) • POWER: 355 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	Continuous over target area	Between sightings	At conclusion of experiment
Power	355 W	355 W	355 W	40 W	0 W
Data	---	200 B/S	200 B/S	---	---
Film	---	---	---	---	---
Manpower	1/2	1	0	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS: Cannot be used simultaneously with active radar.

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 30. MICROWAVE RADIOMETER/SCATTEROMETER

1) PHYSICAL REQUIREMENTS:

- SIZE: 1.4 m^3 (50 ft^3)
- WEIGHT: 310 Kg (680 lb)
- POWER: 330 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min (warm-up)	10 min	Continuous over target area	Between sightings	At conclusion of experiment
Power	330 W	330 W	330 W	40 W	0 W
Data	---	80 B/S	80 B/S	---	---
Film	---	---	---	---	---
Manpower	1	1	1/2	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 31. SFERICS RECEIVER

1) PHYSICAL REQUIREMENTS:

- SIZE: $0.35\ m^3$ ($11.7\ ft^3$)
- WEIGHT: 32.3 Kg (71 lb)
- POWER: 60 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	10 min.	Continuous over target area	Between sightings	At conclusion of experiment
Power	60 W	60 W	60 W	30 W	0 W
Data	---	780 B/S	780 B/s	---	---
Film	---	---	---	---	---
Manpower	1	1	1/4	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS: Cannot be used simultaneously with active radar.

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 32. WIDE ANGLE VIEWER/HYDROGEN ALPHA LINE VIEWER

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.106 m^3 (3.8 ft^3)
- WEIGHT: 25 Kg (55 lb)
- POWER: 10 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	5 min.	5 min	1 min./target	Between sightings	At conclusion of experiments
Power	30 W	30 W	30 W	0 W	0 W
Data	---	---	Real-time TV display	---	---
Film	---	---	---	---	---
Manpower	1	1	1	0	0
Special					

3) CONFLICTS WITH OTHER SENSORS:

MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 33. DATA COLLECTION SYSTEM

1) PHYSICAL REQUIREMENTS:

- SIZE: 0.035 m^3 (1.24 ft^3) • WEIGHT: 14.2 Kg (31 lb) • POWER: 92 W

2) REQUIREMENTS:

Requirement	EVENTS				
	Set Up/ Modification 1	Checkout Calibration 2	Operate 3	Standby 4	Shut Down 5
Duration (Standard, or Min/Max)	10 min. (warm-up)	0	Continuous over target area (240 min capacity)	Between data collection intervals	At conclusion of experiments
Power	92 W	0 W	92 W	0 W	0 W
Data	---	---	30 KHz on each of 5 tracks (240 min. capacity)	---	---
Film	---	---	---	---	---
Manpower	---	---	---	---	---
Special					

3) CONFLICTS WITH OTHER SENSORS:

(1) Transfers data to ground station in 6 minutes at 240 KHz bandwidth.

Instrument: 18

FIRST EVENT \ SECOND EVENT	1	2	3	4	5
1		X			
2			X	X	
3				X	X
4			X		
5	X				

COMMENTS:

- This matrix represents a nighttime cycle only. During daylight the instrument is in event 4
- The instrument is only sequenced through the events once every other day. During off days the instrument is in event 5.
- Events 1 and 2 occur once every 2 days, 30 minutes prior to the first nighttime period
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 2 and event 3
  - There is time between targets
- Event 5 occurs at the end of every other day after the last event 3.

Instruments: 19, 20, 21, 22, 23, 24, 26

SECOND EVENT (columns) / FIRST EVENT (rows)

FIRST EVENT \ SECOND EVENT	1	2	3	4	5
1		X	X	X	
2			X	X	
3				X	X
4			X		
5	X				

COMMENTS:

- This matrix represents the daylight cycle only. During eclipse the instrument is in event 4
- Event 2 occurs once every day (minimum separation between repeats - 8 hours)
- Event 1 occurs once at the beginning of the mission
- Event 5 occurs once at the end of the mission after the last event 3
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 (if performed) and event 3
  - There is time between targets

Instruments: 13, 15

SECOND EVENT

FIRST EVENT	1	2	3	4	5
1		X			
2			X	X	
3				X	X
4			X		
5	X				

COMMENTS:

- Event 1 occurs once at the beginning of the mission
- Event 2 occurs once every two hours
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 (if performed) and event 3
  - There is time between targets
- Event 5 occurs after the last event 3.

Instruments: 12, 17

SECOND EVENT

FIRST EVENT	1	2	3	4	5
1		X			
2			X	X	
3				X	X
4			X		
5	X				

COMMENTS:

- Events 1 and 2 occur once, in sequence, at the beginning of the mission
- Event 4 occurs prior to of after event 3 if:
  - There is time between events 2 and 3
  - There is time between targets
- Event 5 occurs after the last event 3.

Instruments: 29, 30, 31

SECOND EVENT

FIRST EVENT	1	2	3	4	5
1		X	X	X	
2			X	X	
3				X	X
4			X		
5	X				

COMMENTS:

- Event 2 occurs once every day (minimum separation between repeats - 8 hours)
- Event 1 occurs once at the beginning of the mission
- Event 5 occurs once at the end of the mission after the last event 3
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 (if performed) and event 3
  - There is time between targets

Instruments: 8, 9, 10A, 10B, 11A, 11B, 14, 16, 25, 27, 28

SECOND EVENT

FIRST EVENT	1	2	3	4	5
1		X	X	X	
2			X	X	
3				X	X
4			X		
5	X				

COMMENTS:

- Event 2 follows event 1 once a day. Minimum separation between repeats of event 2 is 8 hours.
- Even 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 event 2 (if performed) and event 3
  - There is time between targets
- Event 5 occurs after the last event 3

Instruments: 1, 2, 3, 4, 5, 6, 7

FIRST EVENT \ SECOND EVENT	1	2	3	4	5
1		X	X	X	
2			X	X	
3				X	X
4			X		
5	X				

COMMENTS:

- This matrix represents the daylight cycle only, the instrument is shut down during eclipse
- Event 2 follows event 1 once every two days
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 (if performed) and event 3
  - There is a target left to be covered before eclipse, after the last event 3
- Event 5 is followed by event 1, 5 minutes prior to daylight

APPENDIX D

AESOP OUTPUT TIMELINES

- EXPERIMENTS
- SENSORS
- POWER

APPENDIX D

APPENDIX D

AESOP OUTPUT TIMELINES

The output of AESOP consists of experiment schedules and resources summaries (timelines and tabular summaries). This Appendix shows the following outputs:

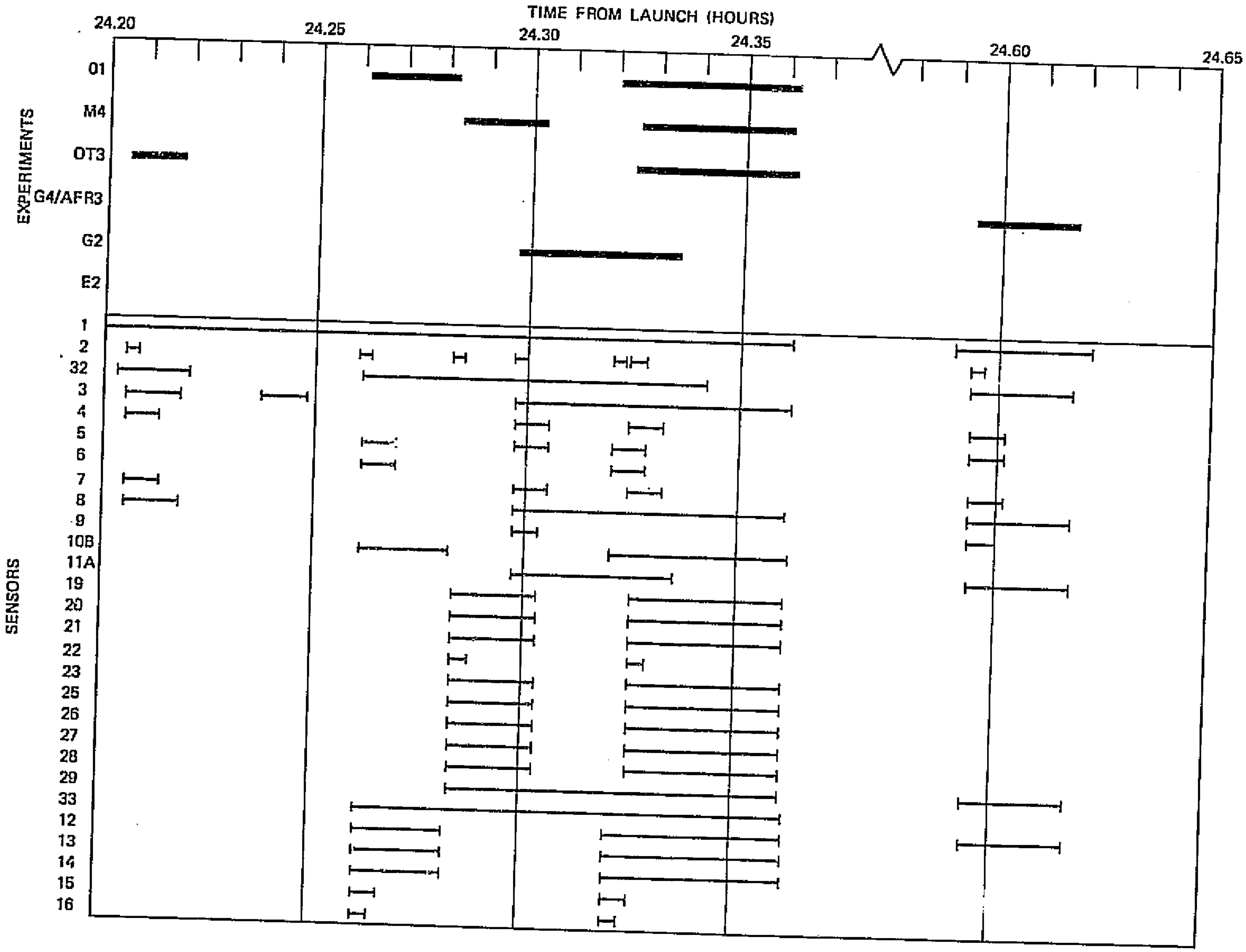
- Experiment timeline
- Sensor utilization timeline
- Power utilization timeline

Each timeline is two days in length because a coverage cycle in the pollution reference mission is that long (i.e., the time history will repeat every 48 hours).

EXPERIMENT/SENSOR TIMELINE

FOR THE FIRST TWO-DAY CYCLE

OF THE FIVE-DAY BASELINE POLLUTION MISSION


TIME FROM LAUNCH (HOURS)
24.20
24.25
24.30
24.35
24.60
24.65
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
7
8
9
10B
11A
19
20
21
22
23
25
26
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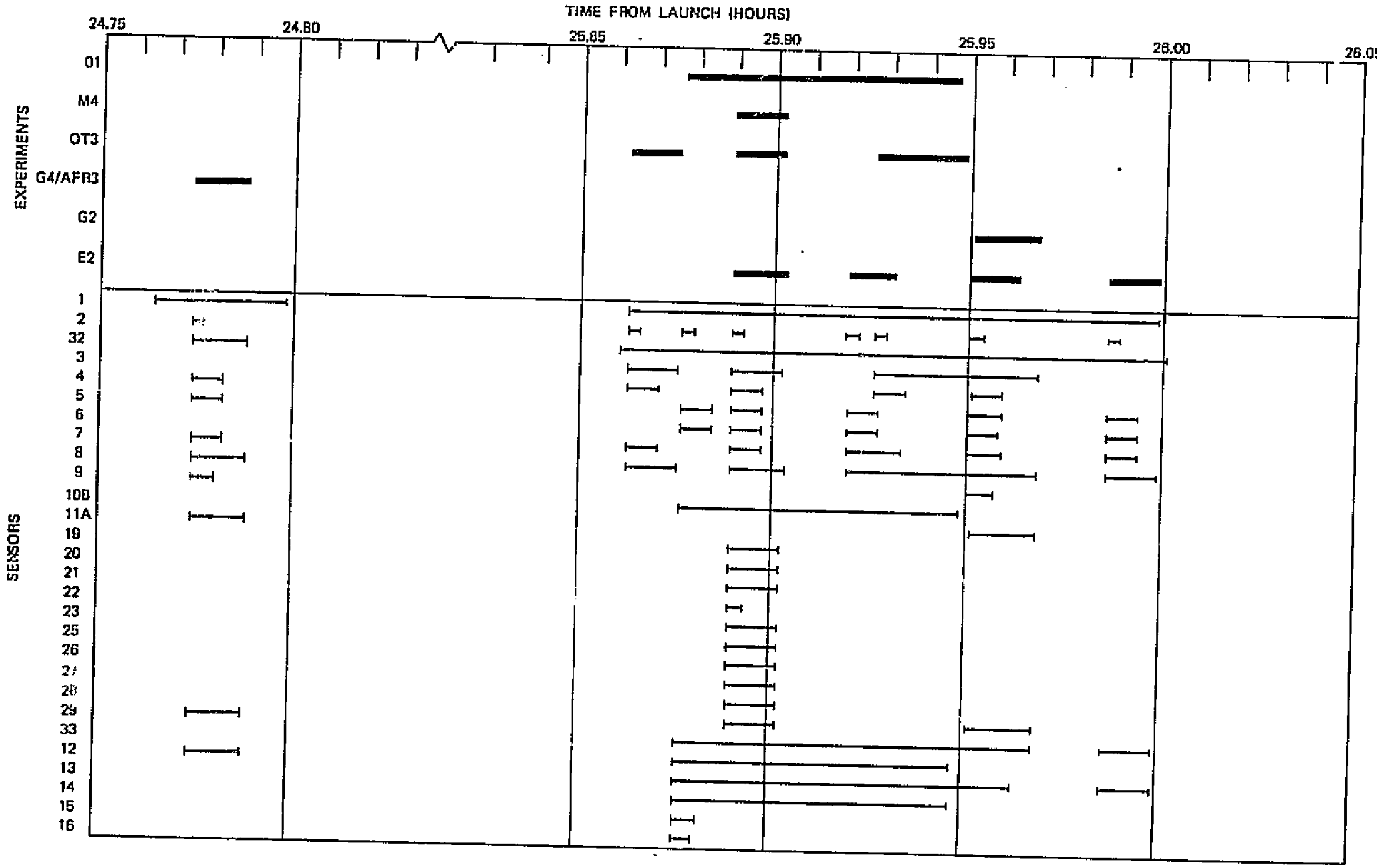
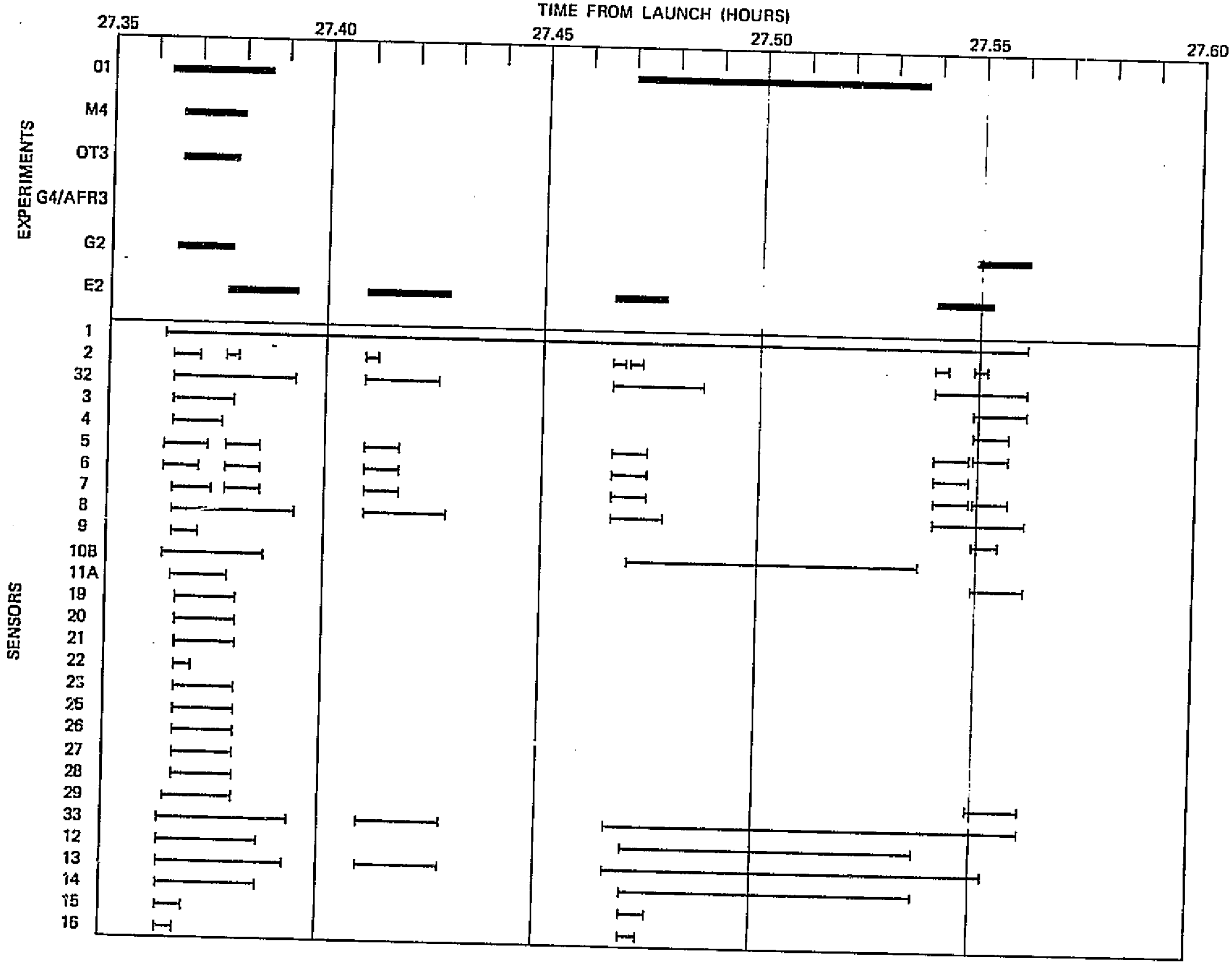
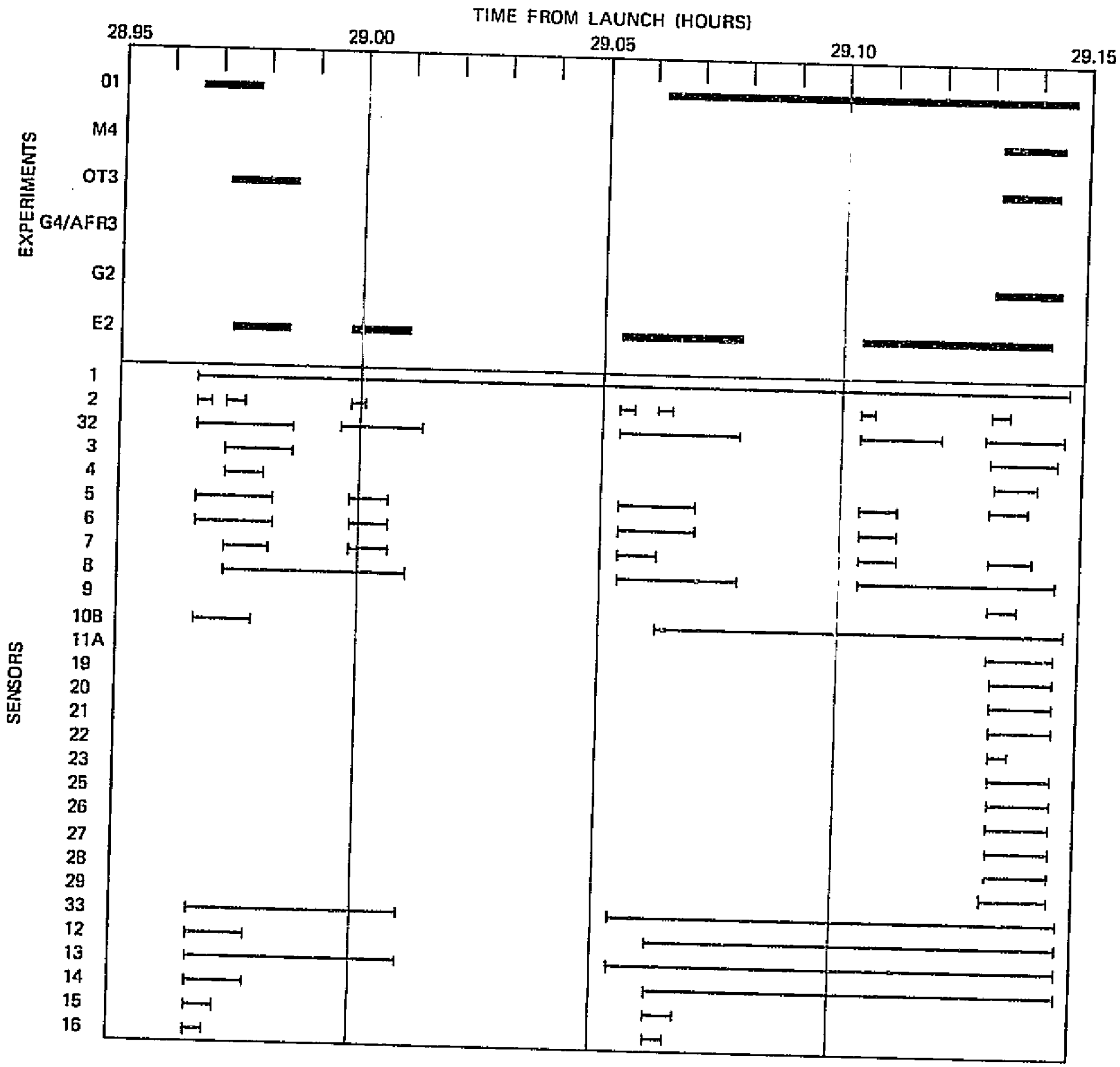
28
29
33
12
13
14
15
16


TIME FROM LAUNCH (HOURS)
24.75
24.80
25.85
25.90
25.95
26.00
26.05
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
7
8
9
10B
11A
19
20
21
22
23
25
26
27
28
29
33
12
13
14
15
16



TIME FROM LAUNCH (HOURS)
27.35
27.40
27.45
27.50
27.55
27.60
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
7
8
9
10B
11A
19
20
21
22
23
25
26
27
28
29
33
12
13
14
15
16


TIME FROM LAUNCH (HOURS)
28.95
29.00
29.05
29.10
29.15
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
7
8
9
10B
11A
19
20
21
22
23
25
26
27
28
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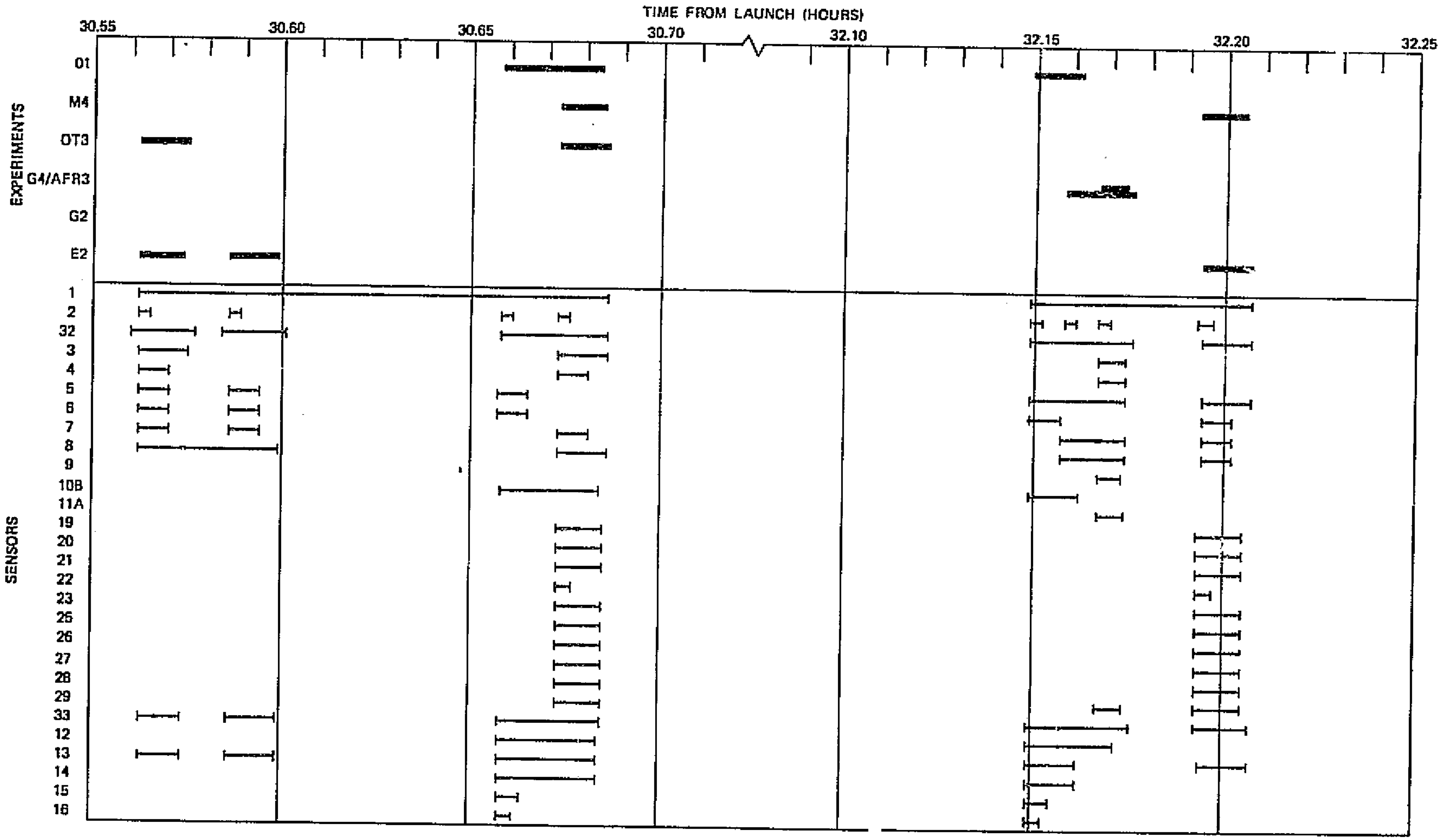
33
12
13
14
15
16


TIME FROM LAUNCH (HOURS)
30.55
30.60
30.65
30.70
32.10
32.15
32.20
32.25
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
7
8
9
10B
11A
19
20
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22
23
25
26
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28
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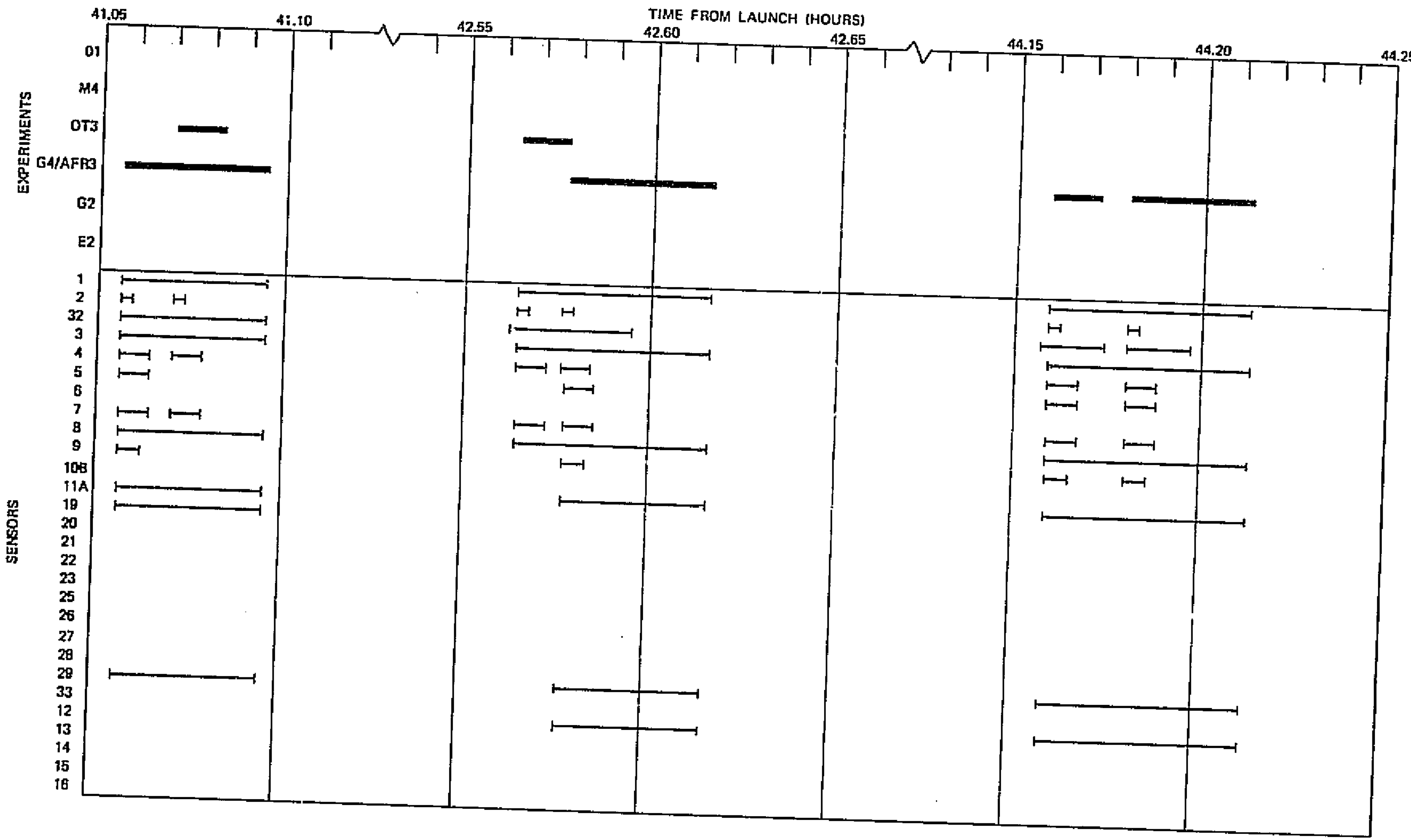
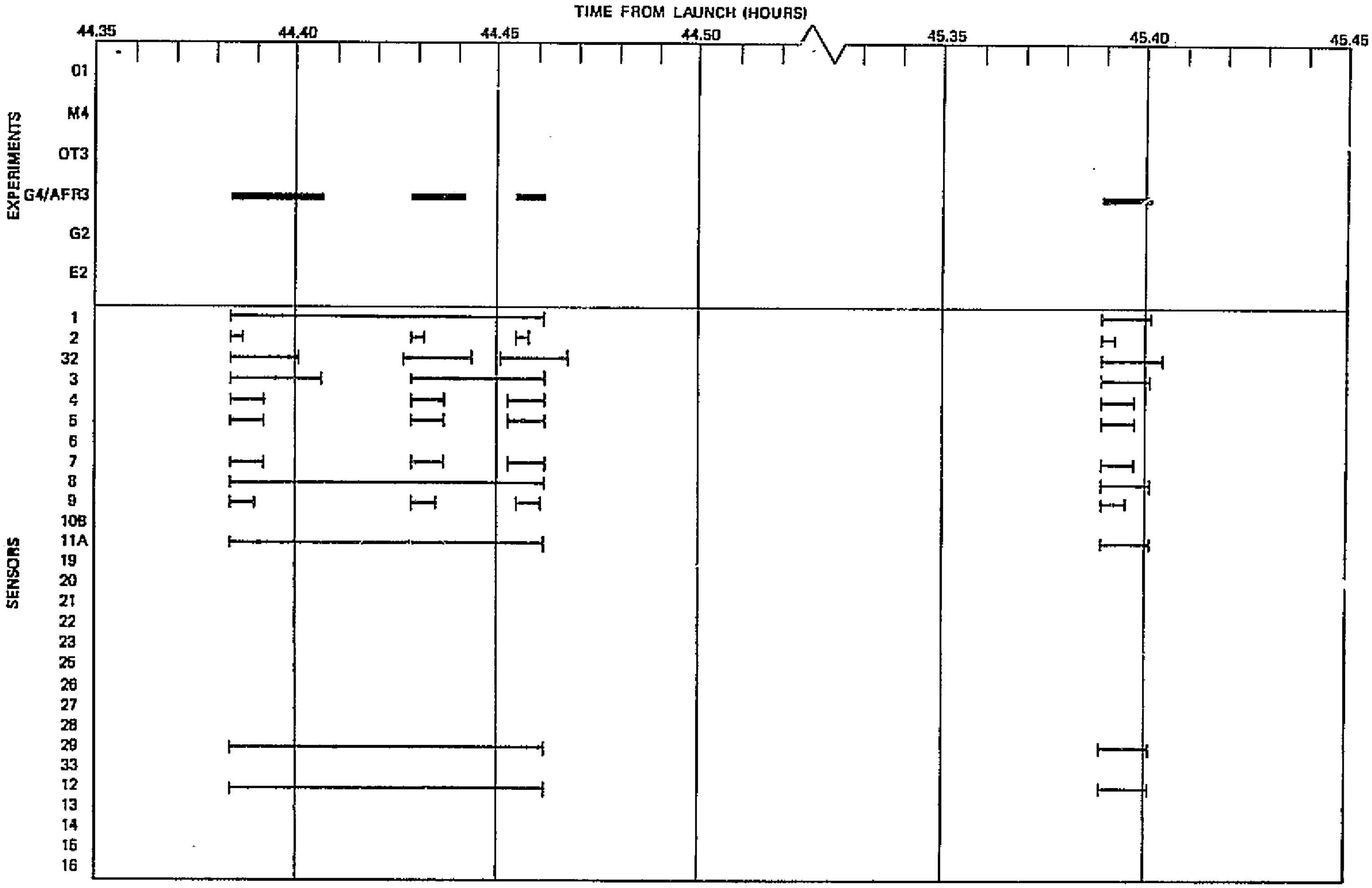
13
14
15
16


TIME FROM LAUNCH (HOURS)
41.05
41.10
42.55
42.60
42.65
44.15
44.20
44.25
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
7
8
9
10B
11A
19
20
21
22
23
25
26
27
28
29
33
12
13
14
15
16



TIME FROM LAUNCH (HOURS)
44.35
44.40
44.45
44.50
45.35
45.40
45.45
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
7
8
9
10B
11A
19
20
21
22
23
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26
27
28
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33
12
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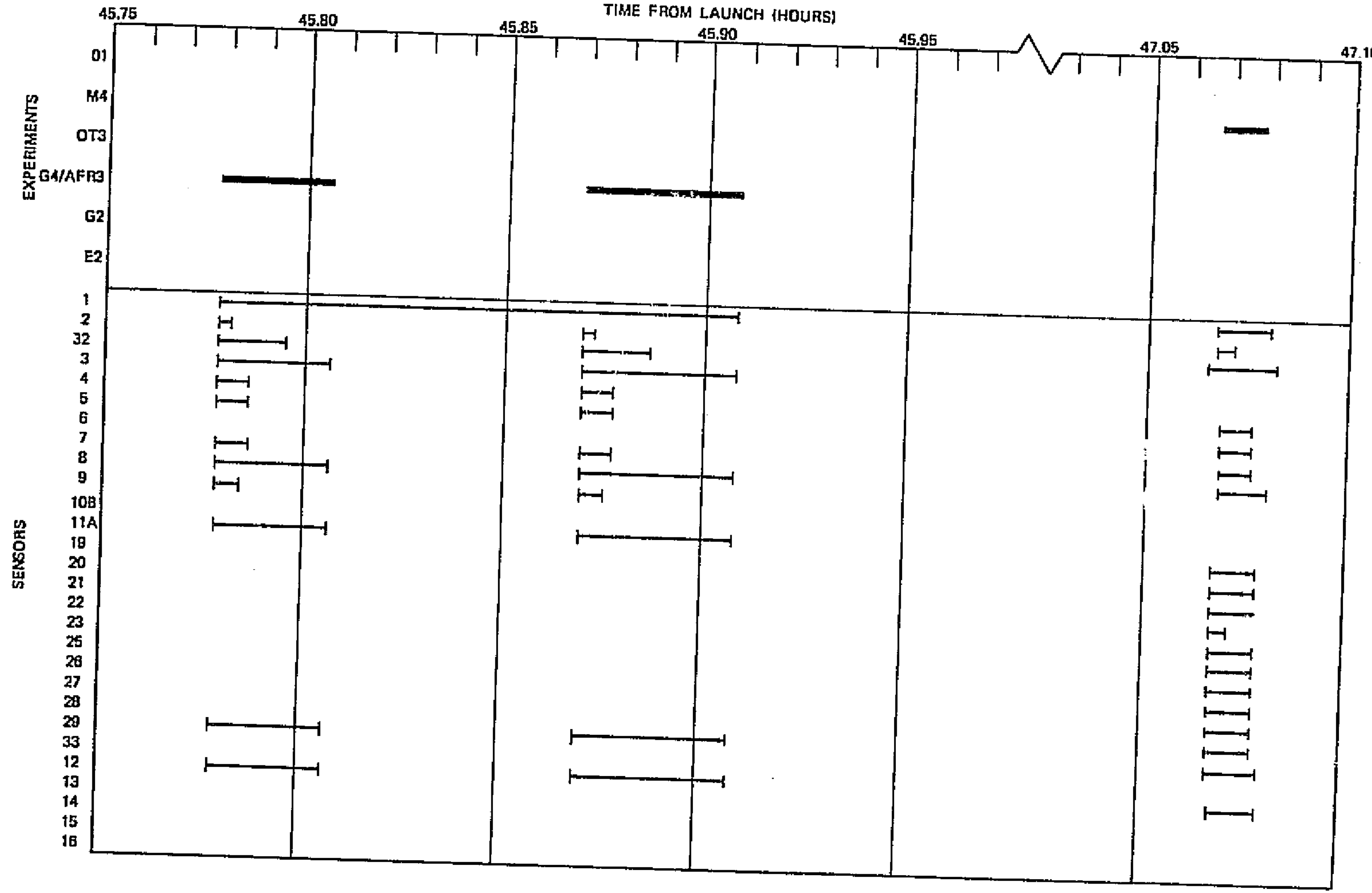
15
16


TIME FROM LAUNCH (HOURS)
45.75
45.80
45.85
45.90
45.95
47.05
47.10
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
7
8
9
10B
11A
19
20
21
22
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25
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28
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33
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15
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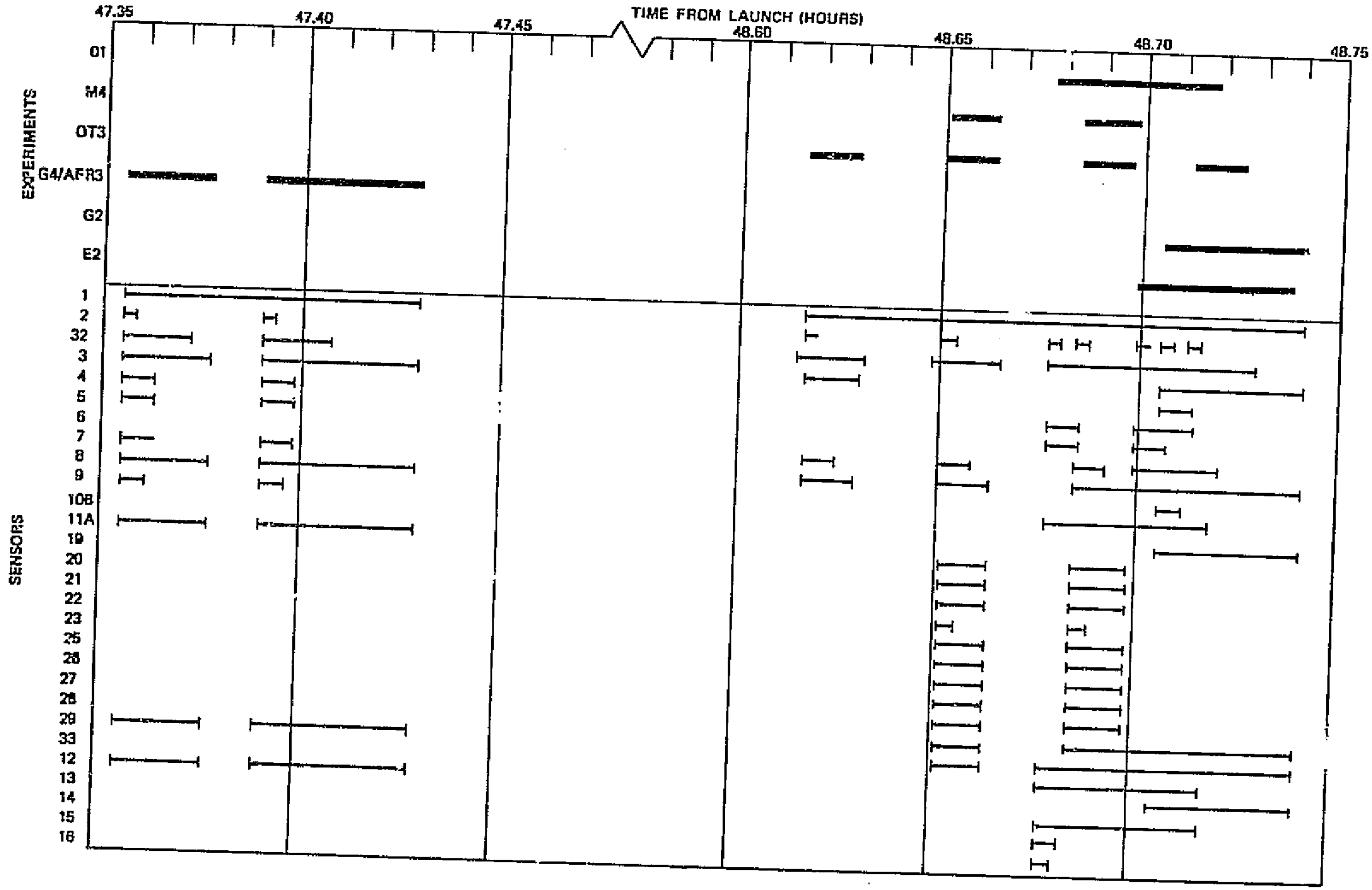
TIME FROM LAUNCH (HOURS)
47.35
47.40
47.45
48.60
48.65
48.70
48.75
EXPERIMENTS
O1
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
7
8
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10B
11A
19
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25
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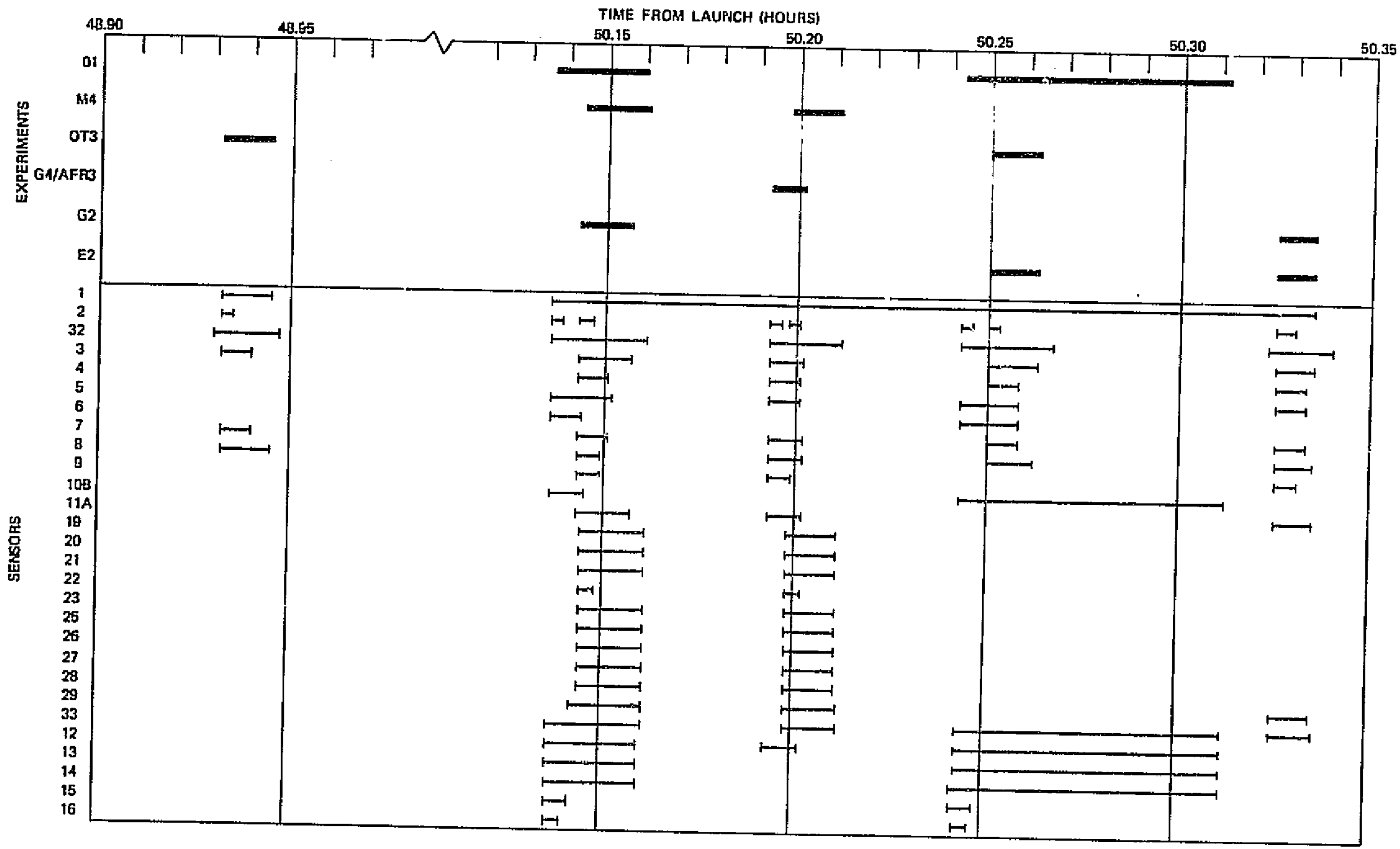
15
16


TIME FROM LAUNCH (HOURS)
48.90
48.95
50.15
50.20
50.25
50.30
50.35
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
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10B
11A
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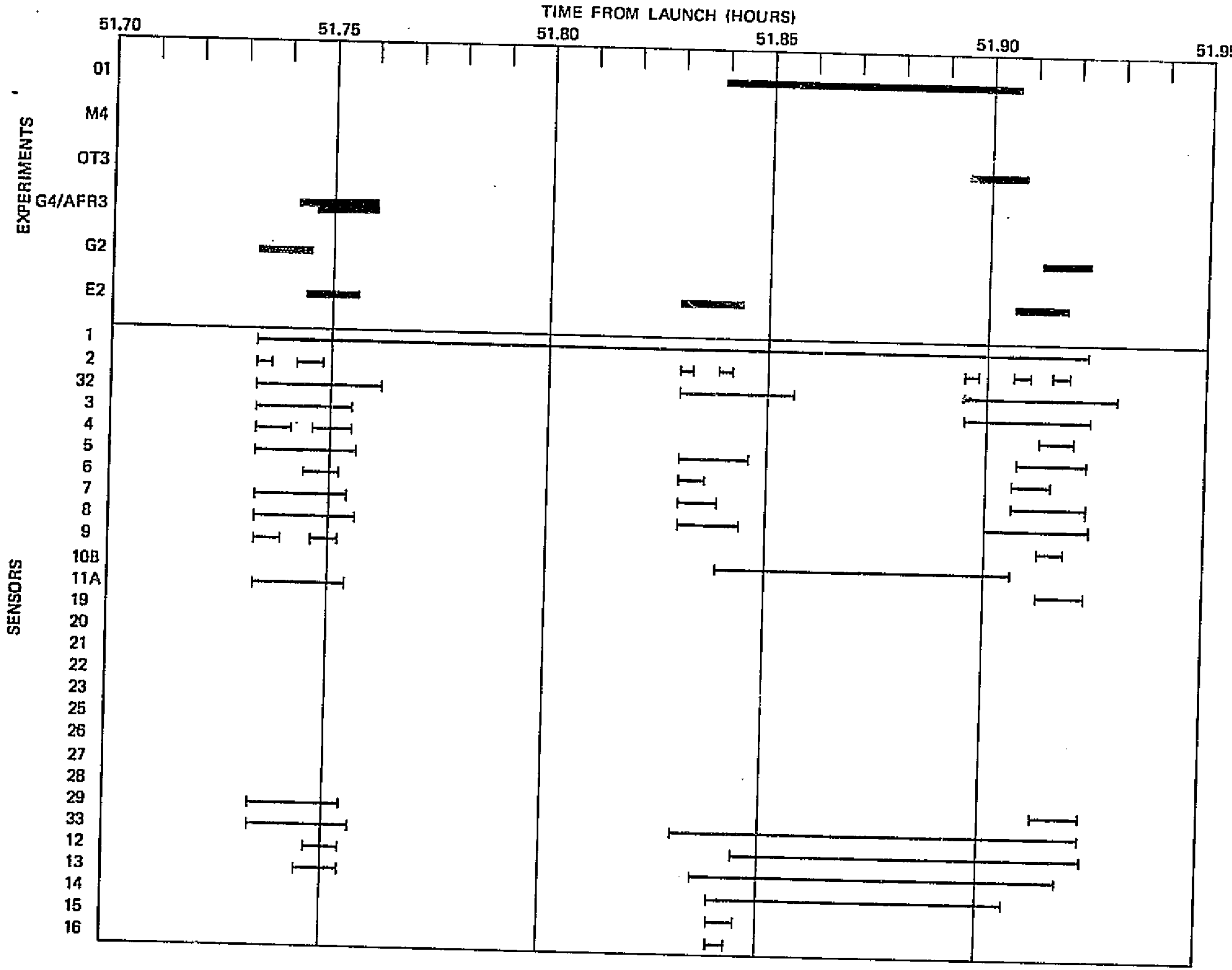
TIME FROM LAUNCH (HOURS)
51.70
51.75
51.80
51.85
51.90
51.95
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
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10B
11A
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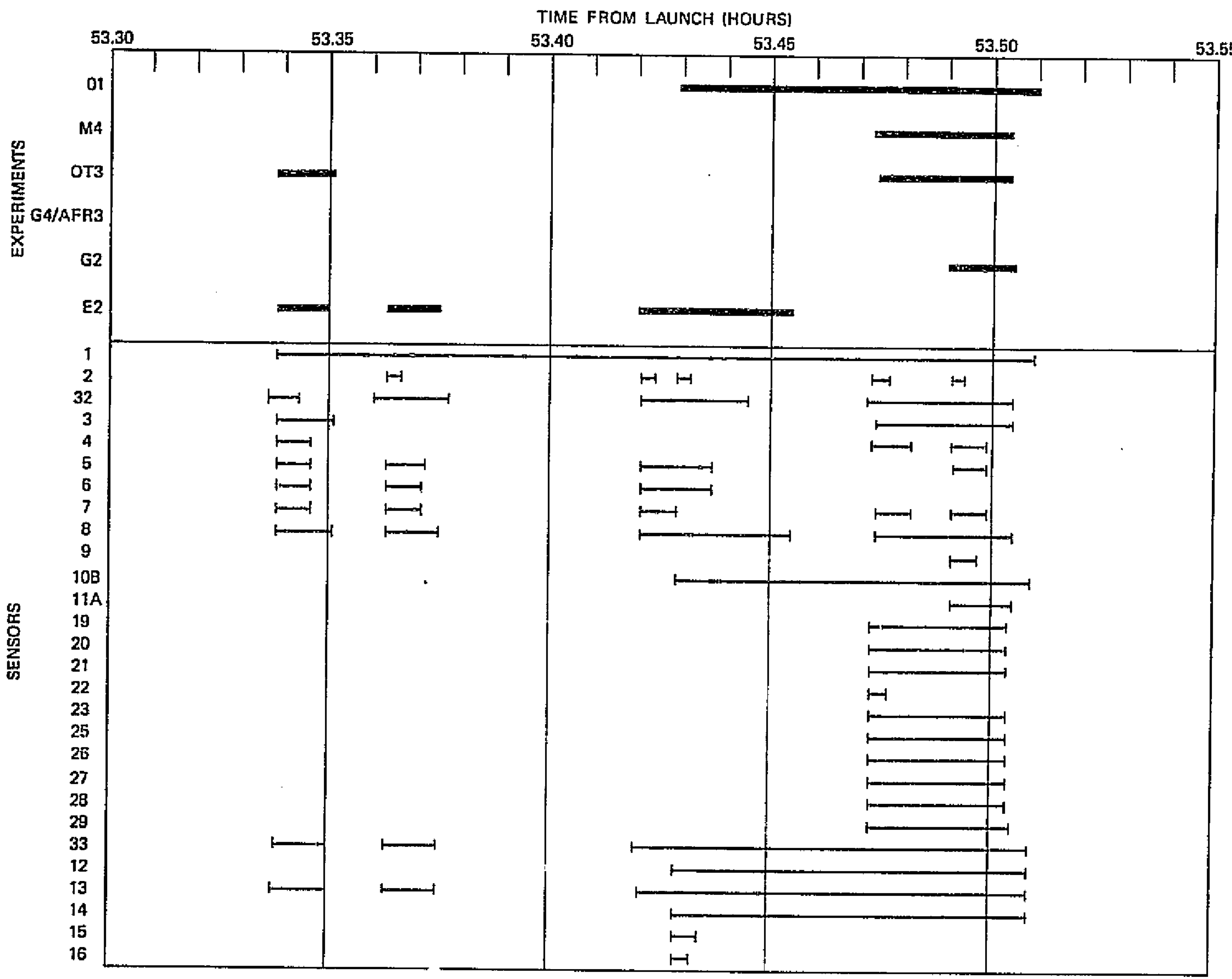
TIME FROM LAUNCH (HOURS)
53.30
53.35
53.40
53.45
53.50
53.55
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
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32
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10B
11A
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15
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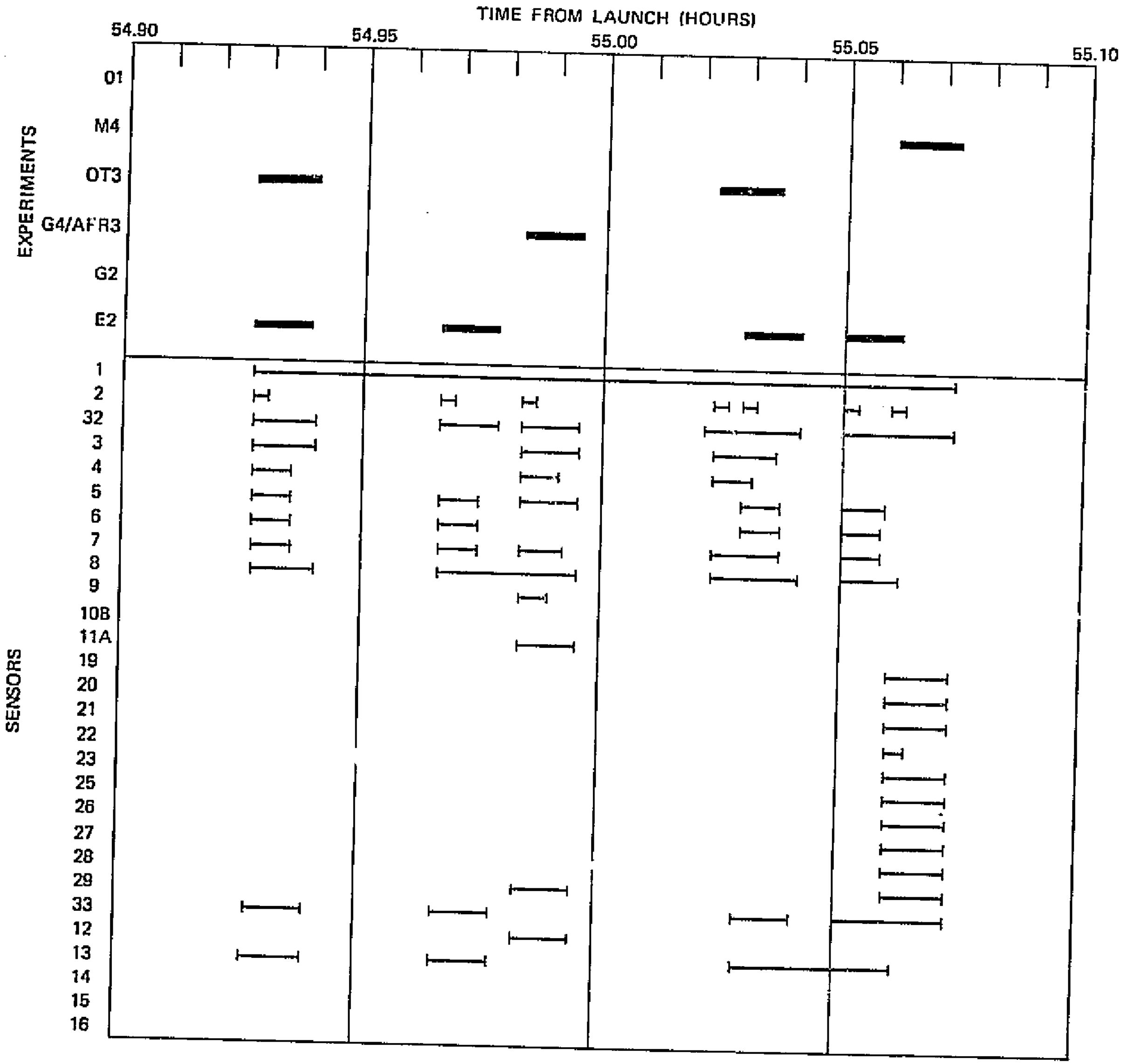
TIME FROM LAUNCH (HOURS)
54.90
54.95
55.00
55.05
55.10
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
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10B
11A
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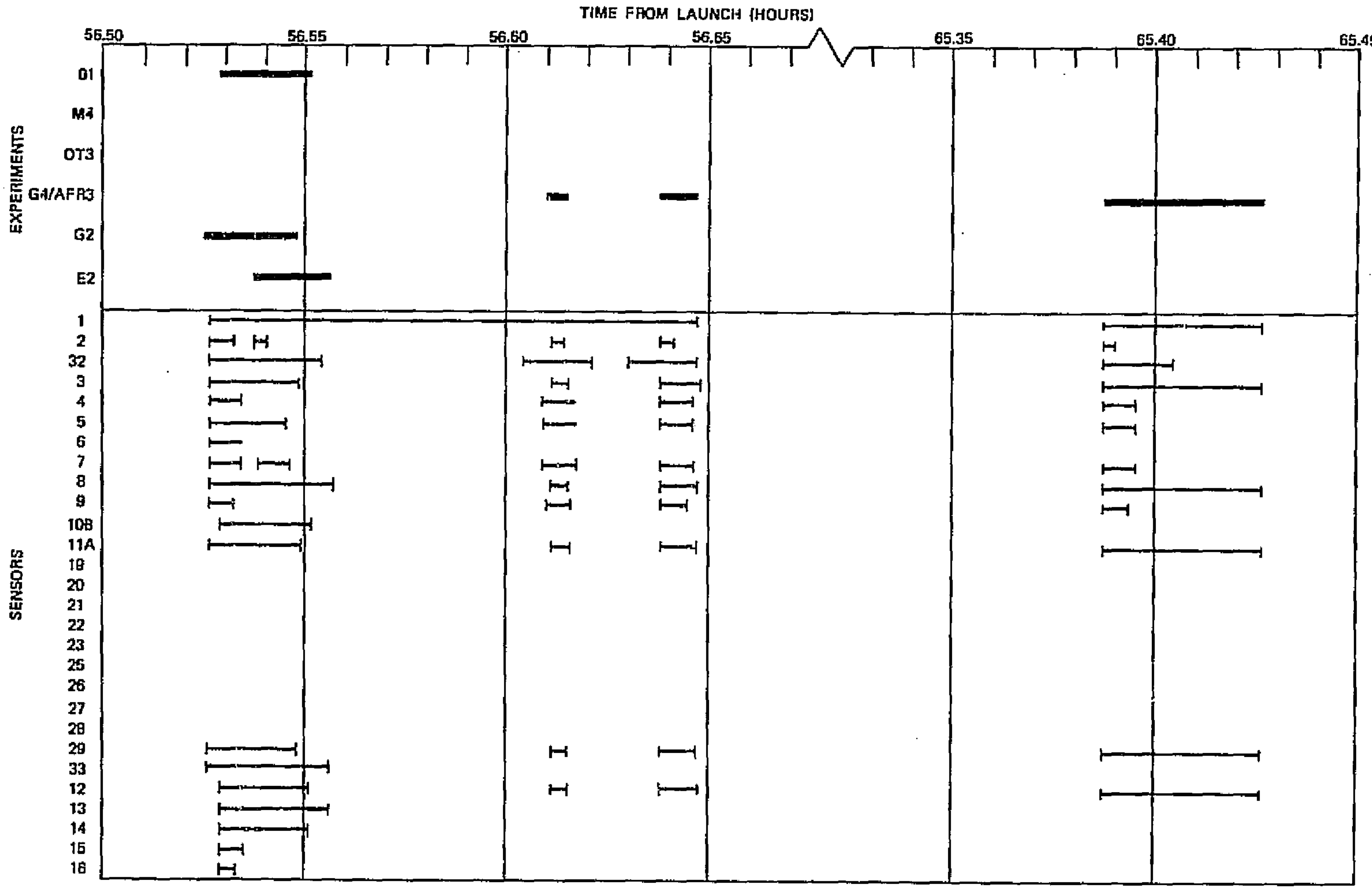
16


TIME FROM LAUNCH (HOURS)
56.50
56.55
56.60
56.65
65.35
65.40
65.45
EXPERIMENTS
01
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
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8
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10B
11A
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13
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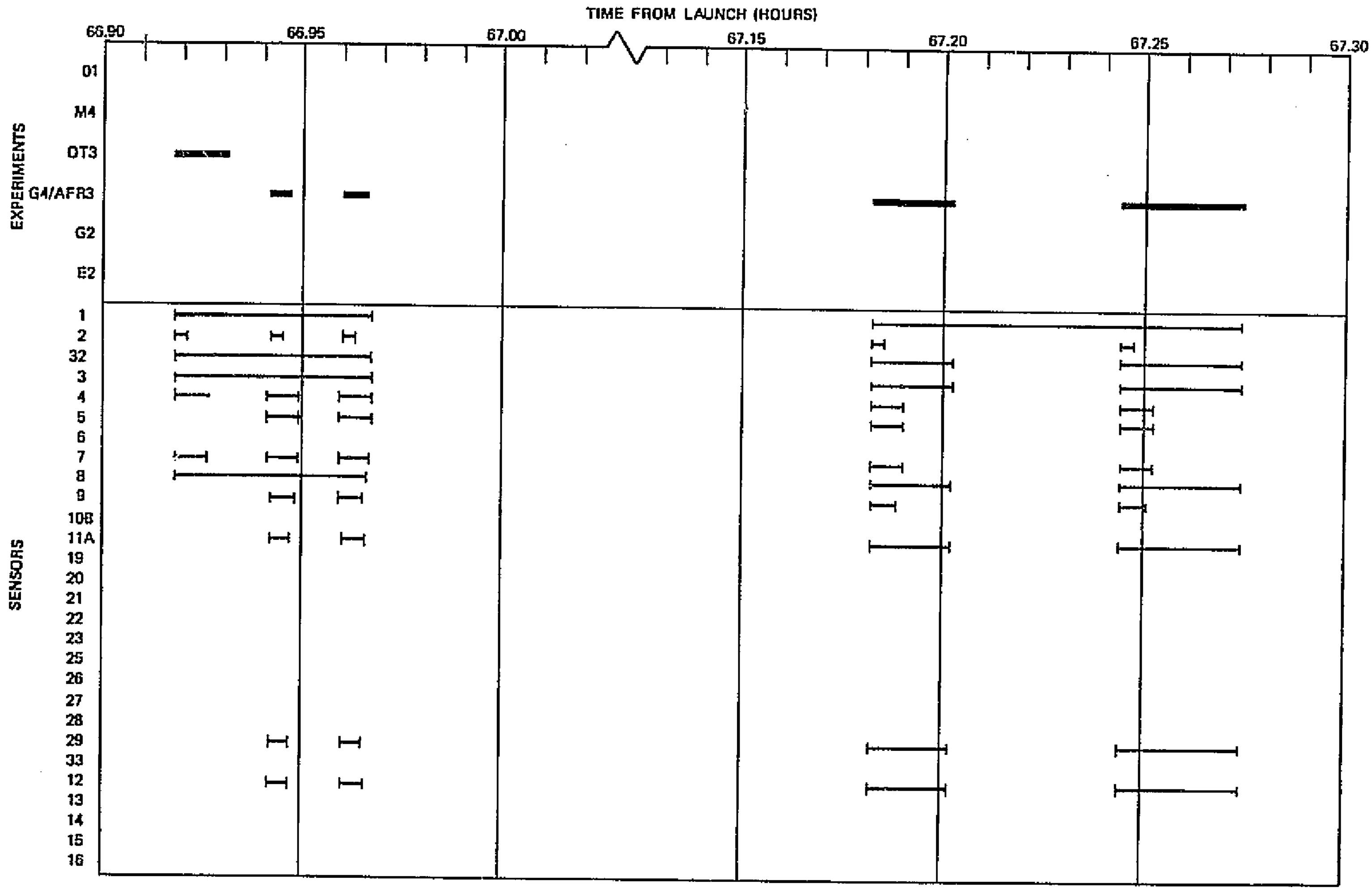
15
16



TIME FROM LAUNCH (HOURS)
66.90
66.95
67.00
67.15
67.20
67.25
67.30
EXPERIMENTS
01
M4
DT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
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10B
11A
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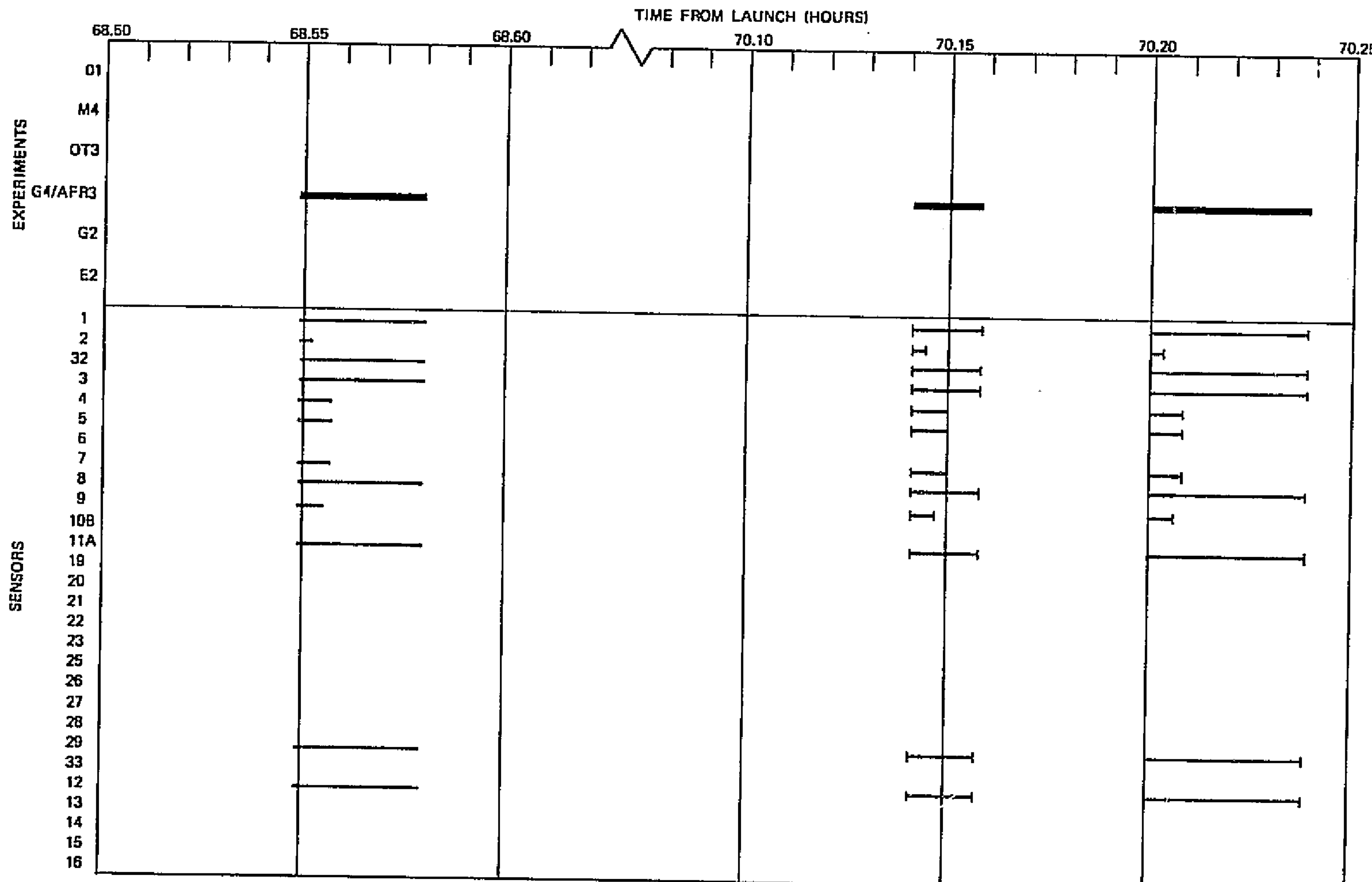
16



TIME FROM LAUNCH (HOURS)
68.50
68.55
68.60
70.10
70.15
70.20
70.25
EXPERIMENTS
O1
M4
OT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
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8
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10B
11A
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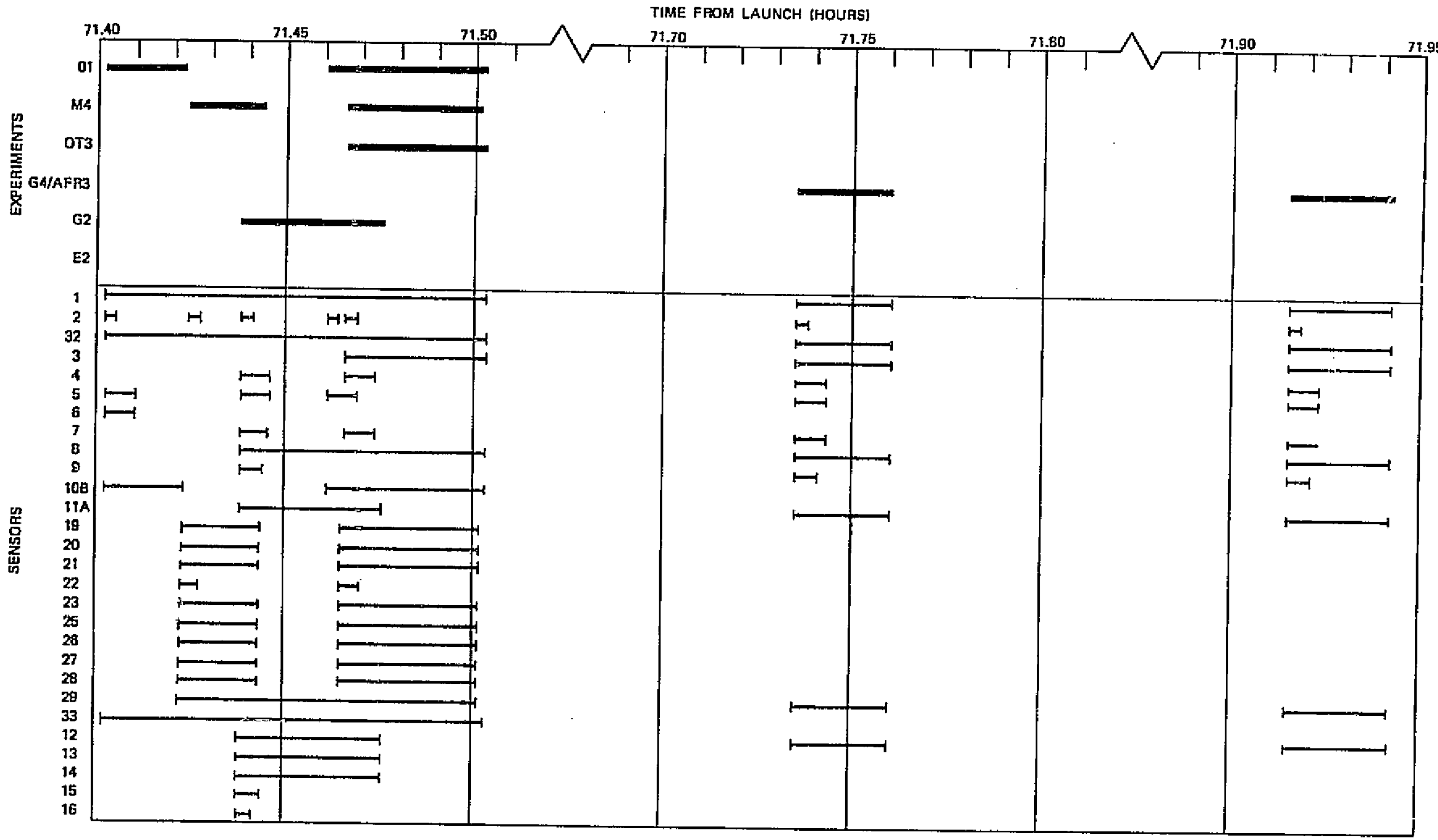
15
16


TIME FROM LAUNCH (HOURS)
71.40
71.45
71.50
71.70
71.75
71.80
71.90
71.95
EXPERIMENTS
01
M4
DT3
G4/AFR3
G2
E2
SENSORS
1
2
32
3
4
5
6
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9
10B
11A
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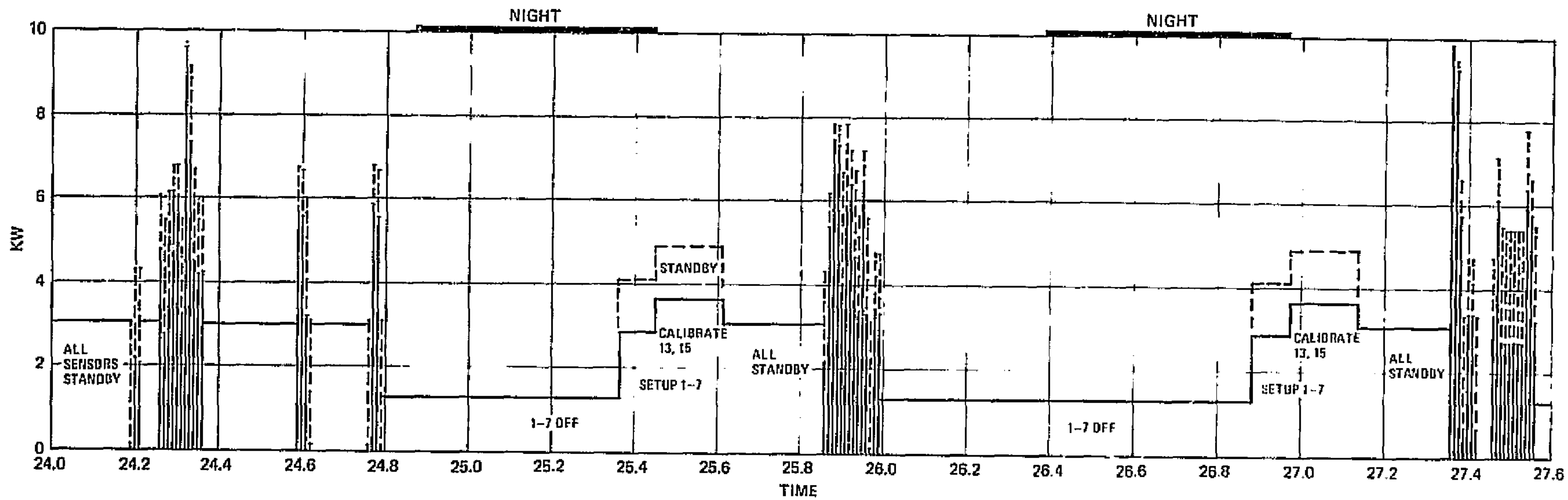
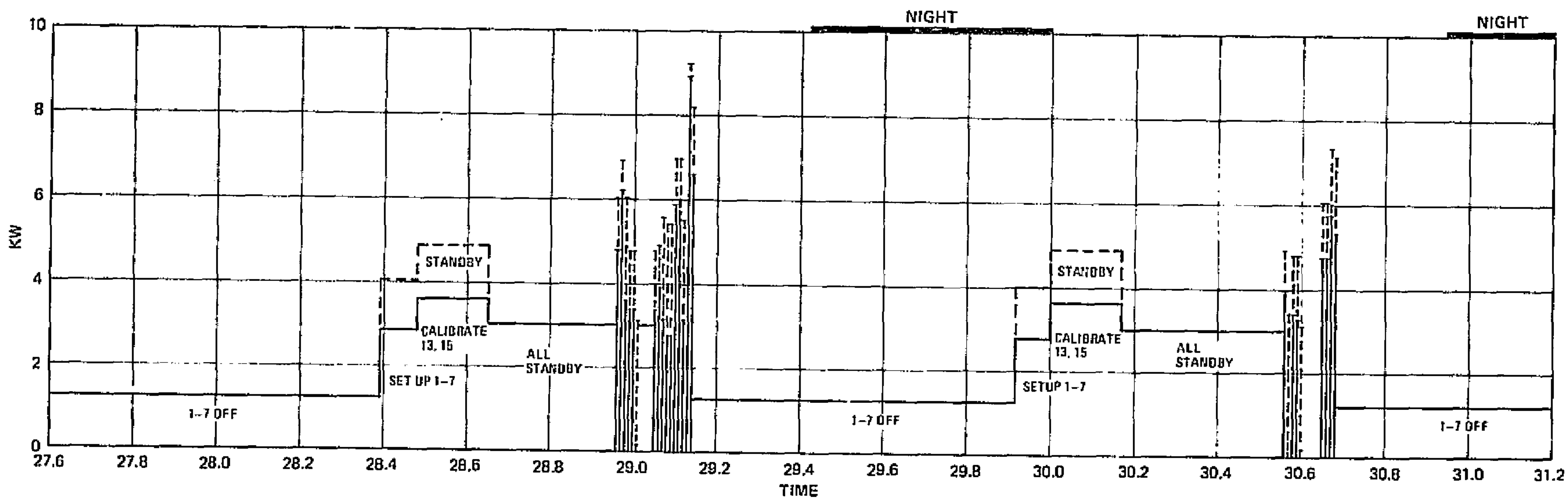
15
16

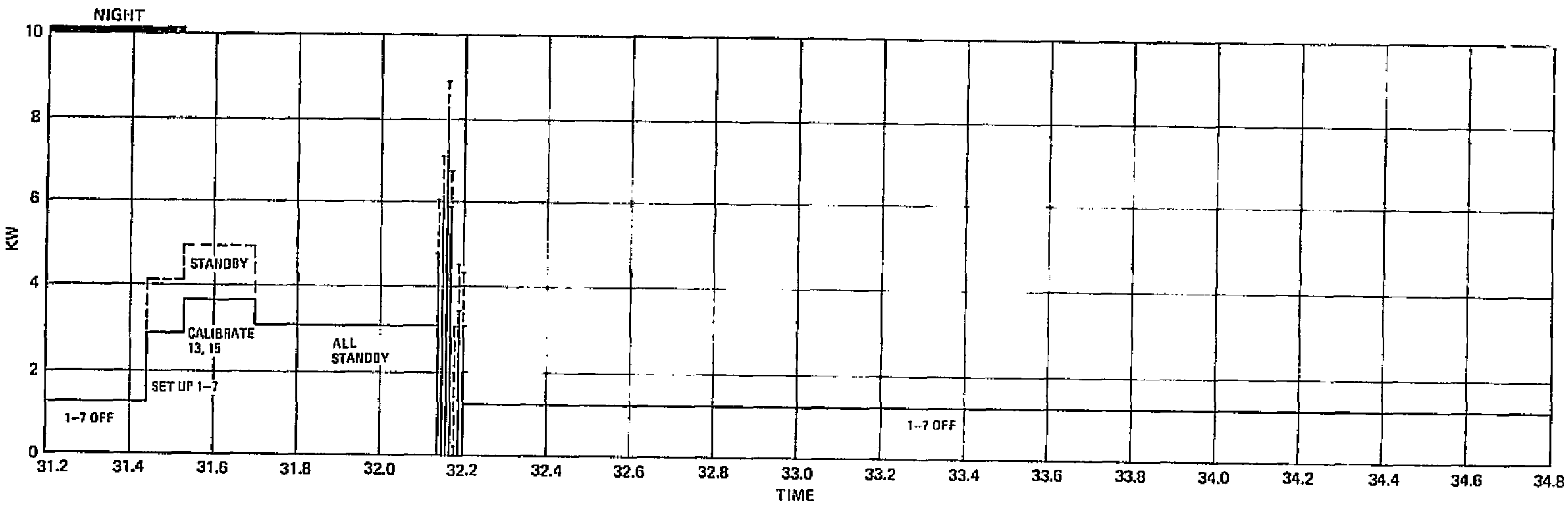
POWER TIMELINE

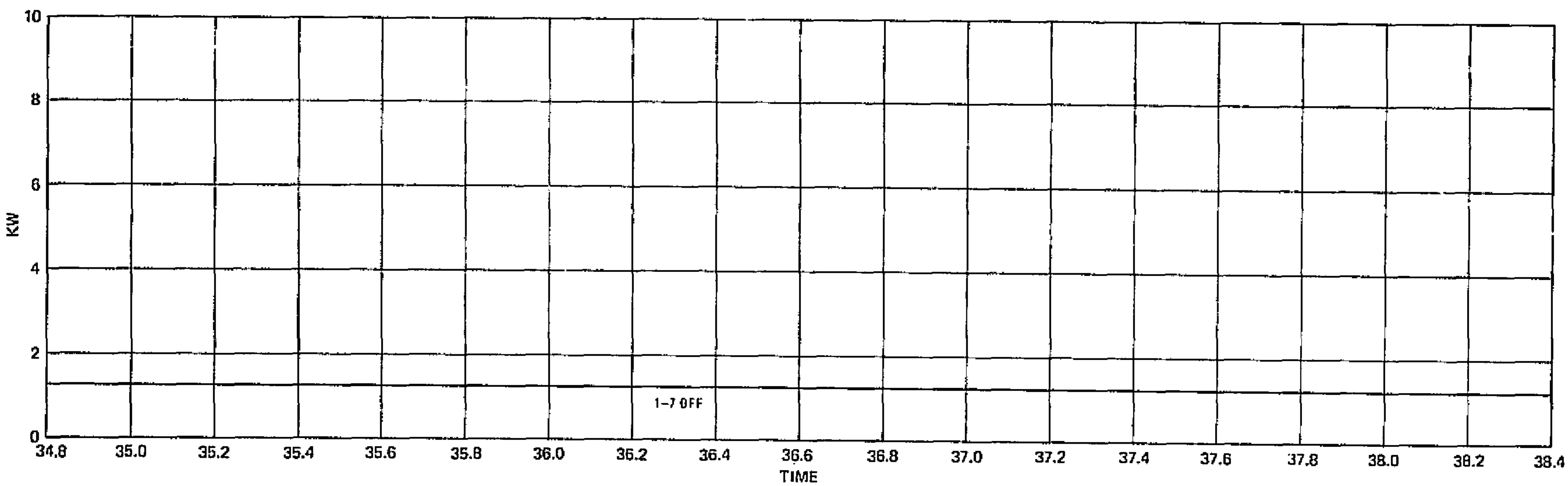
FOR THE FIRST TWO-DAY CYCLE

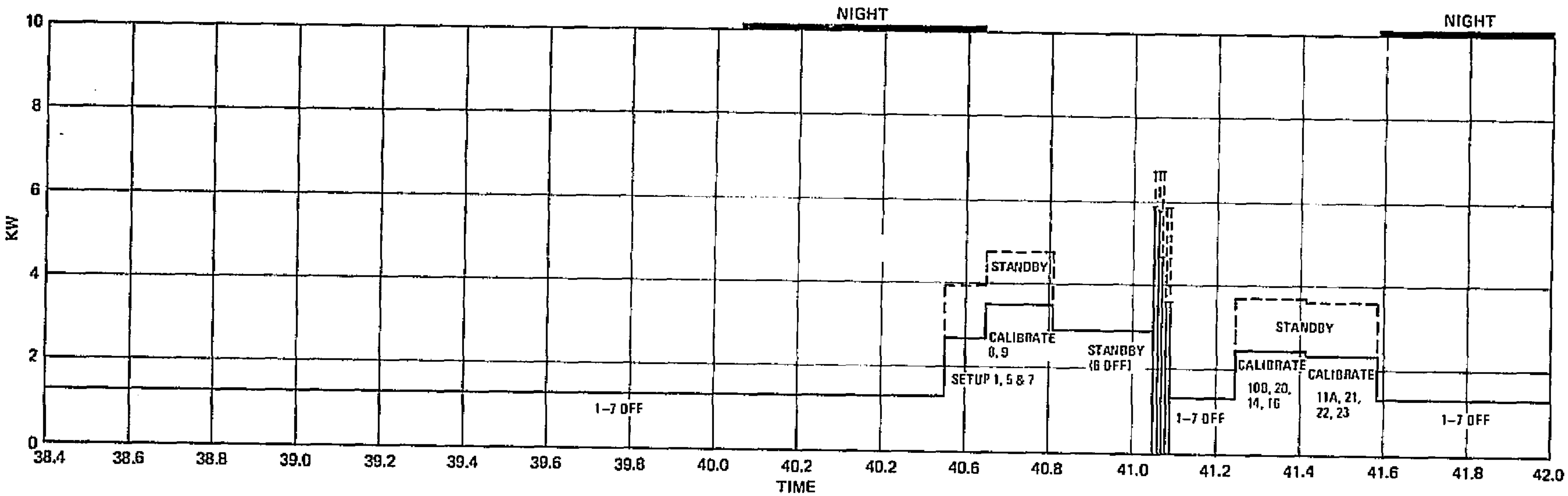
OF THE FIVE-DAY BASELINE POLLUTION MISSION

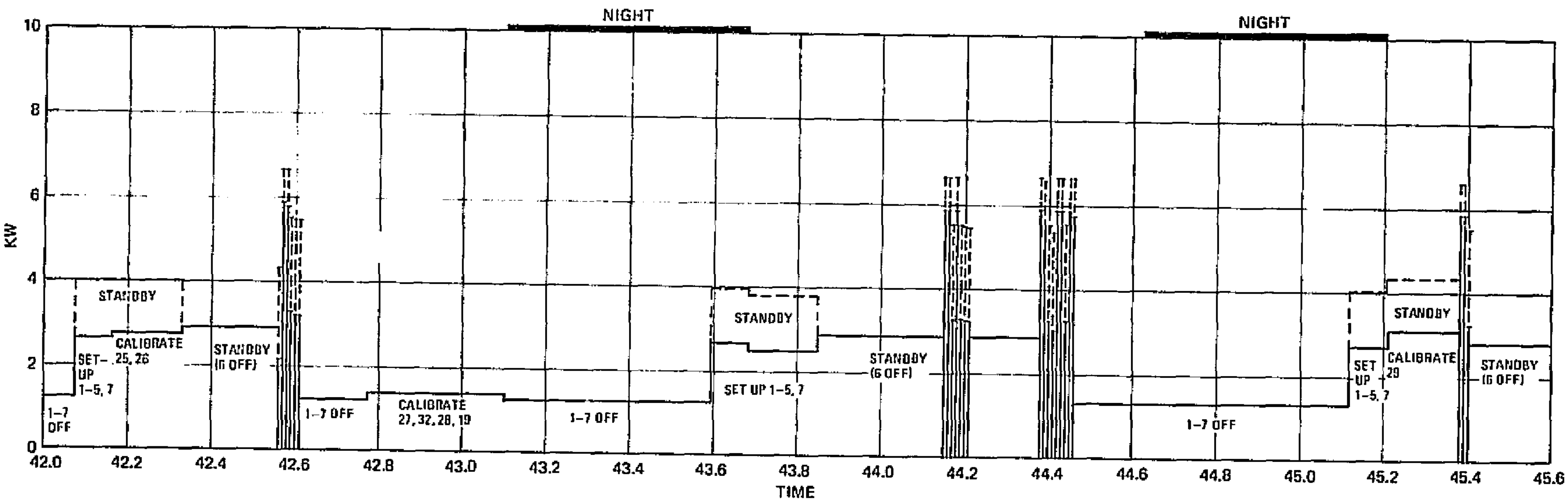

NIGHT
NIGHT
KW
ALL SENSORS STANDBY
STANDBY
CALIBRATE 13, 15
SETUP 1-7
1-7 OFF
ALL STANDBY
CALIBRATE 13, 15
SETUP 1-7
1-7 OFF
ALL STANDBY
TIME

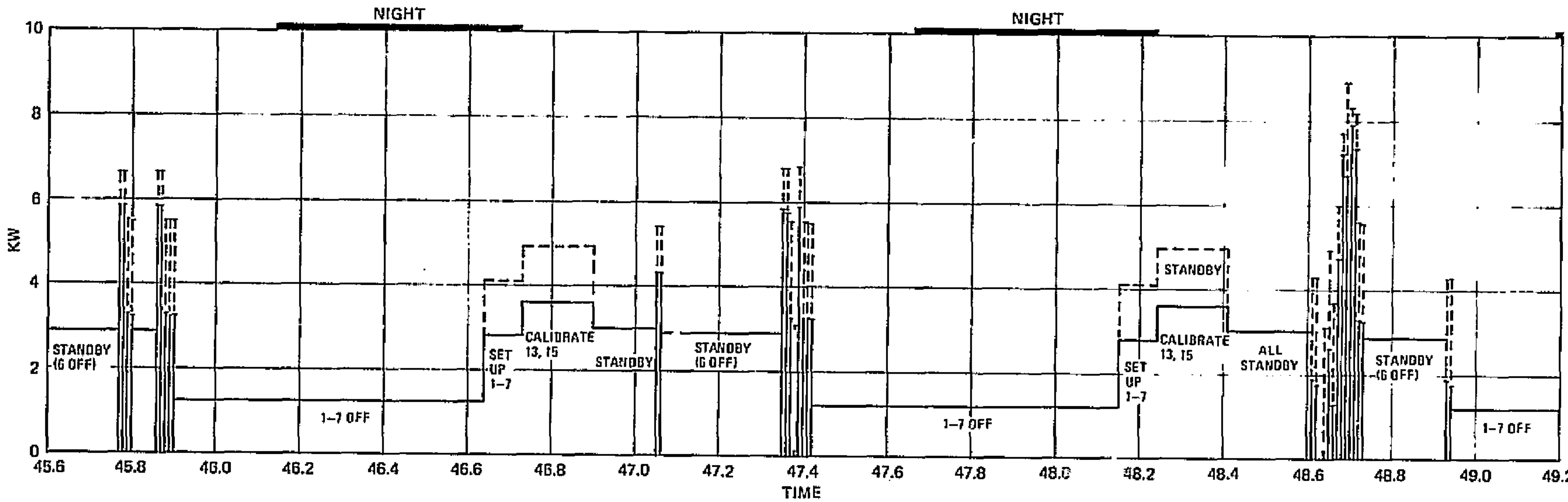

NIGHT
NIGHT
KW
STANDBY
CALIBRATE 13, 15
SET UP 1-7
1-7 OFF
ALL STANDBY
STANDBY
CALIBRATE 13, 15
SETUP 1-7
1-7 OFF
ALL STANDBY
1-7 OFF
TIME

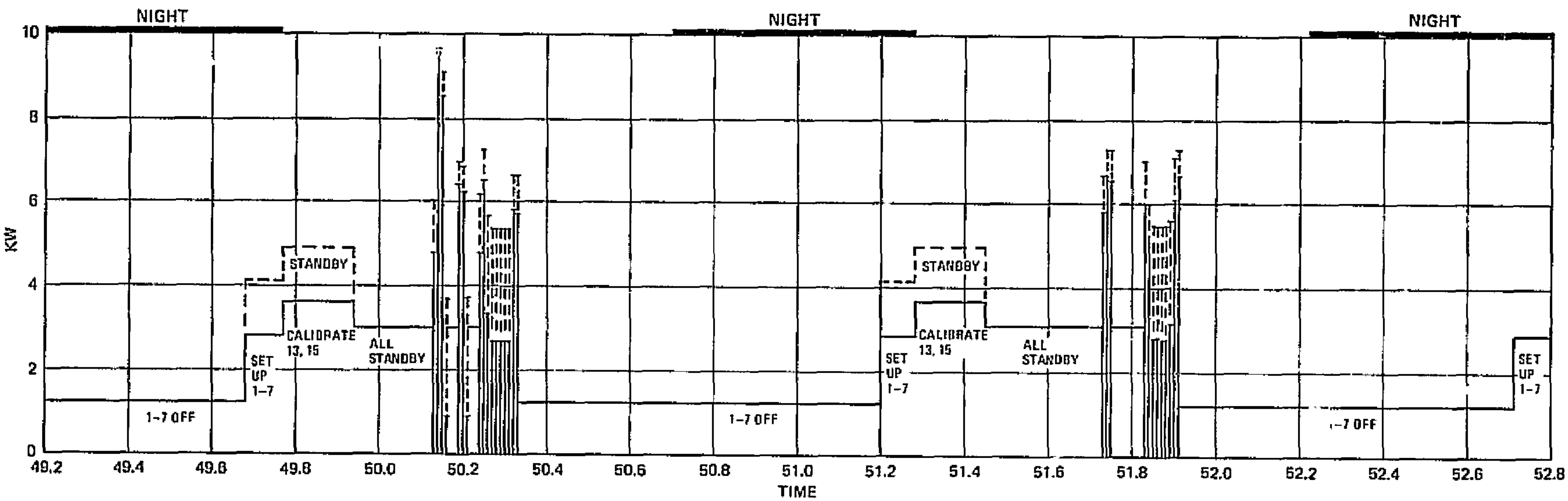

NIGHT
KW
STANDBY
CALIBRATE
13, 15
ALL
STANDBY
SET UP 1–7
1–7 OFF
1–7 OFF
TIME

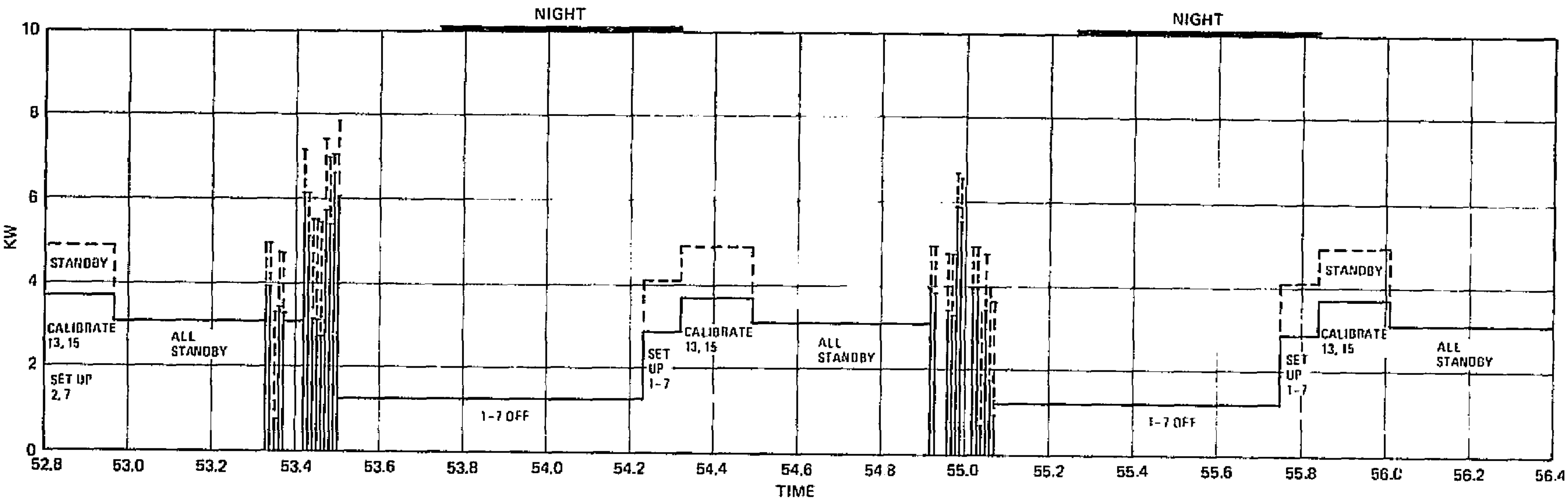

KW
1–7 OFF
TIME

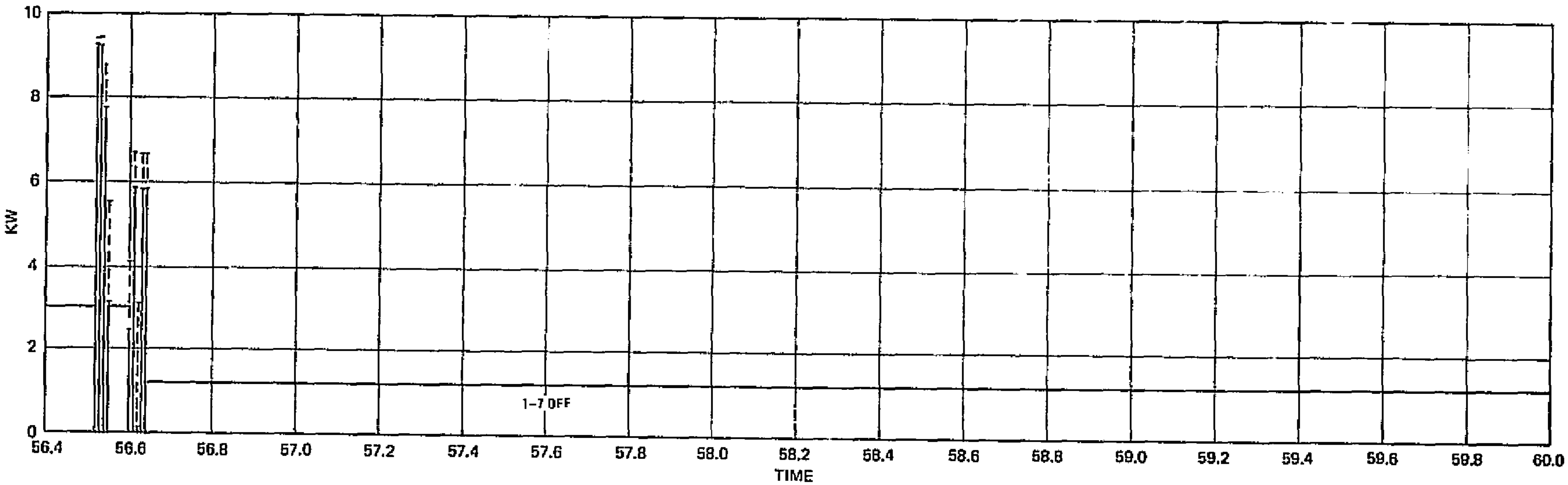

NIGHT
NIGHT
KW
TIME
STANDBY
CALIBRATE 8, 9
SETUP 1, 5 & 7
STANDBY (6 OFF)
1–7 OFF
STANDBY
CALIBRATE 10B, 20, 14, 16
CALIBRATE 11A, 21, 22, 23
1–7 OFF
1–7 OFF

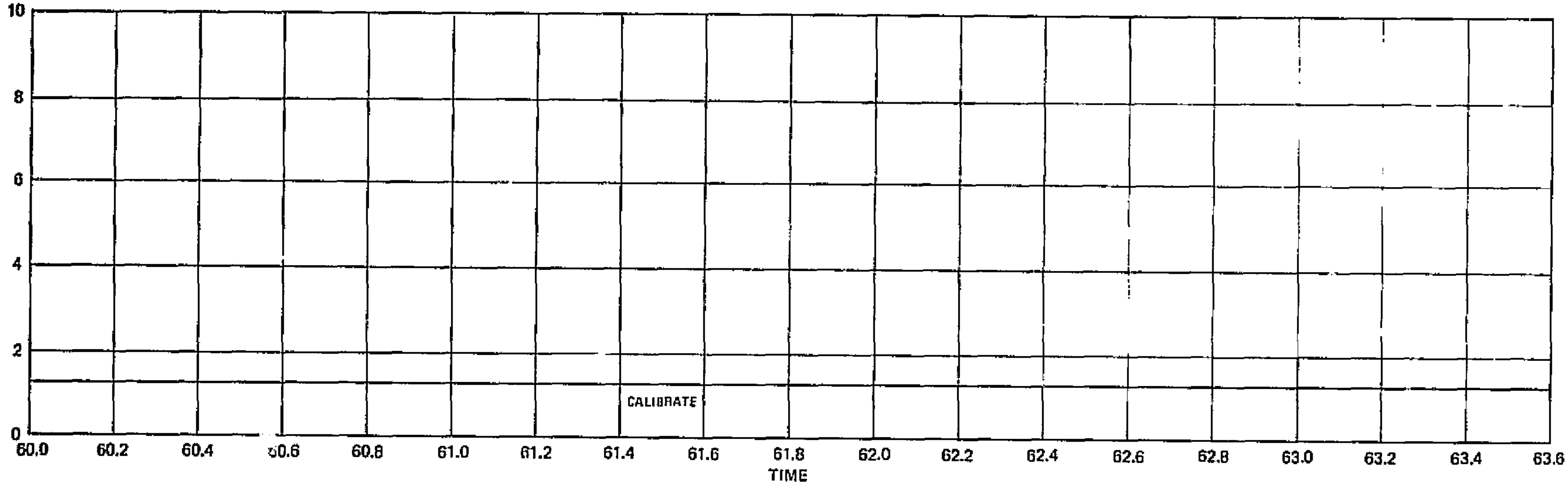

NIGHT
NIGHT
KW
TIME
1–7 OFF
STANDBY
SET-UP 1–5, 7
CALIBRATE 25, 26
STANDBY (6 OFF)
1–7 OFF
CALIBRATE 27, 32, 28, 19
1–7 OFF
STANDBY
SET UP 1–5, 7
STANDBY (6 OFF)
1–7 OFF
SET UP 1–5, 7
STANDBY
CALIBRATE 29
STANDBY (6 OFF)


NIGHT
NIGHT
KW
STANDBY (6 OFF)
1–7 OFF
SET UP 1–7
CALIBRATE 13, 15
STANDBY
STANDBY (6 OFF)
1–7 OFF
SET UP 1–7
STANDBY
CALIBRATE 13, 15
ALL STANDBY
STANDBY (6 OFF)
1–7 OFF
TIME

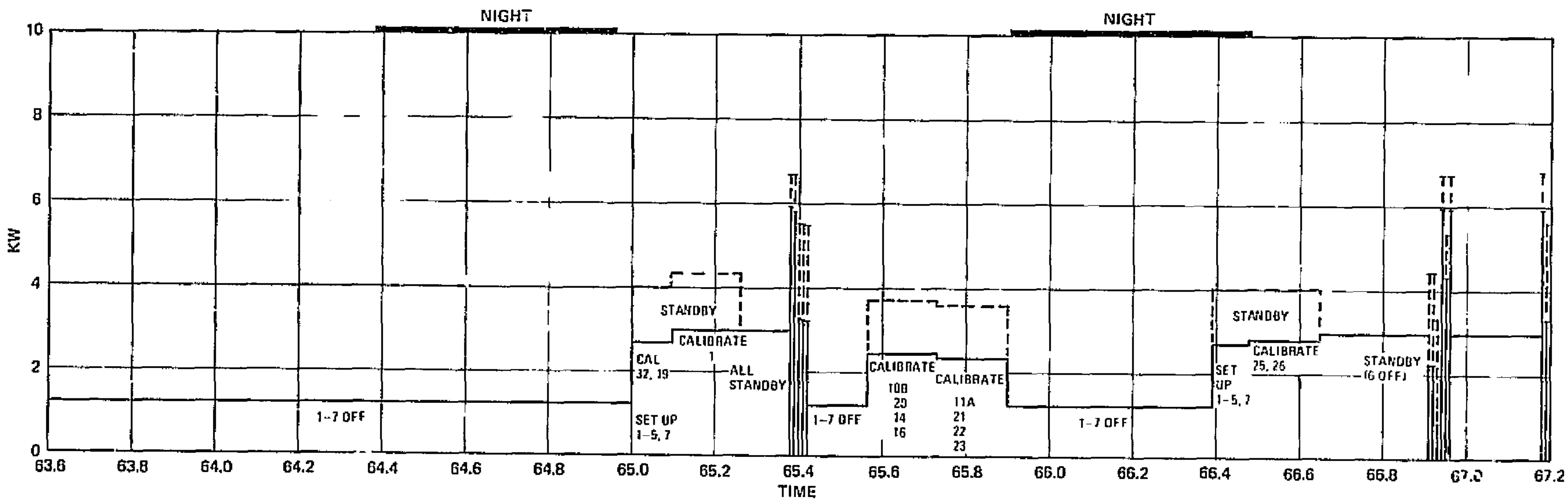

NIGHT
NIGHT
NIGHT
KW
1–7 OFF
SET UP 1–7
STANDBY
CALIBRATE 13, 15
ALL STANDBY
1–7 OFF
SET UP 1–7
STANDBY
CALIBRATE 13, 15
ALL STANDBY
SET UP 1–7
TIME


NIGHT
NIGHT
KW
STANDBY
CALIBRATE 13, 15
SET UP 2, 7
ALL STANDBY
1-7 OFF
SET UP 1-7
CALIBRATE 13, 15
ALL STANDBY
1-7 OFF
SET UP 1-7
STANDBY
CALIBRATE 13, 15
ALL STANDBY
TIME

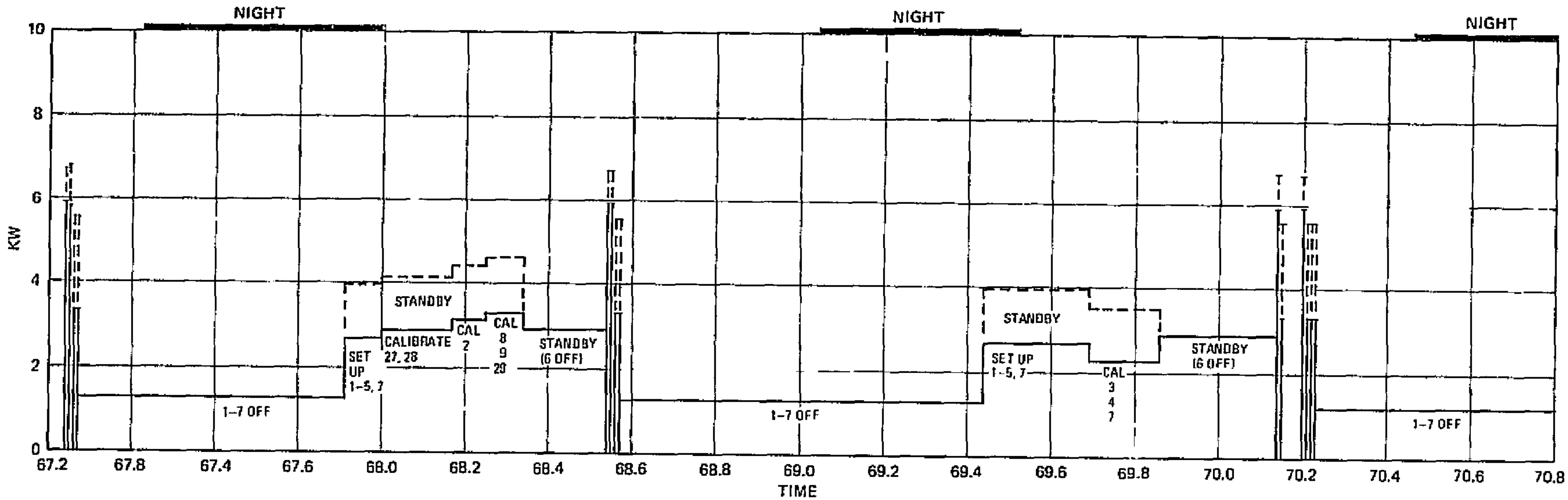

KW
1-7 OFF
TIME

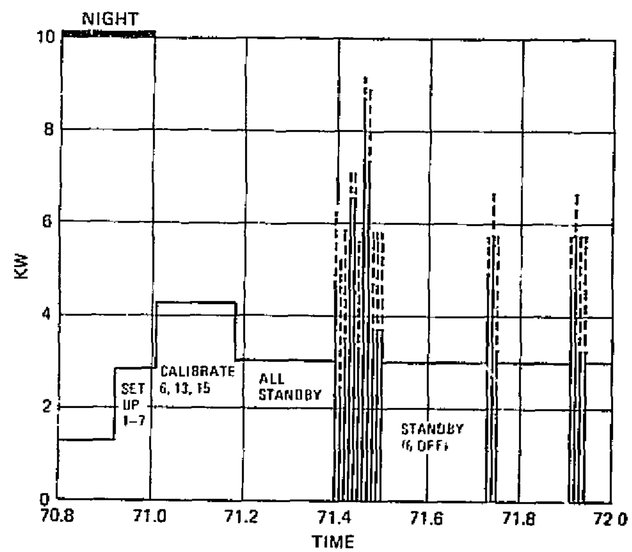


10
8
6
4
2
0
CALIBRATE
60.0
60.2
60.4
60.6
60.8
61.0
61.2
61.4
61.6
61.8
62.0
62.2
62.4
62.6
62.8
63.0
63.2
63.4
63.6
TIME



NIGHT
NIGHT
KW
10
8
6
4
2
0
1-7 OFF
CAL 32, 19
SET UP 1-5, 7
STANDBY
CALIBRATE
1
ALL STANDBY
1-7 OFF
CALIBRATE
10B
20
14
16
CALIBRATE
11A
21
22
23
1-7 OFF
SET UP 1-5, 7
STANDBY
CALIBRATE 25, 26
STANDBY (6 OFF)
63.6
63.8
64.0
64.2
64.4
64.6
64.8
65.0
65.2
65.4
65.6
65.8
66.0
66.2
66.4
66.6
66.8
67.0
67.2
TIME


NIGHT
NIGHT
NIGHT
KW
STANDBY
CALIBRATE 27, 28
CAL 2
CAL 8 9 29
SET UP 1–5, 7
STANDBY (6 OFF)
1–7 OFF
STANDBY
SET UP 1–5, 7
CAL 3 4 7
STANDBY (6 OFF)
1–7 OFF
1–7 OFF
TIME


NIGHT
KW
SET UP 1–7
CALIBRATE 6, 13, 15
ALL STANDBY
STANDBY (6 OFF)
TIME